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ABSTRACT
The Navy computer-managed instruction system (Navy CMI) is a large, multi-site operation. Research findings show that it is yielding benefits in terms of cost savings. During fiscal year 1975, savings of over ten million dollars were realized, mostly due to course reductions ranging from 24 to 80 percent and reductions in on-board students. It has been found that CMI training yields better end-of-course performance levels while maintaining more positive attitudes among students. Attrition rates are lower with CMI, and a continuation of this trend is predicted as the system is expanded. Savings are projected in the potential for expanded capability and competitive procurement using the current system and hardware. Research has shown positive personnel attitudes associated with the integration of personnel and operational procedures using CMI. It is suggested that performance and cost benefits qualify Navy CMI for expansion. (Author/CH)

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PAST, PRESENT, AND FUTURE

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As the reader will discover while digesting this lengthy monograph, the study would not be effected without the total and positive cooperation of many Navy organizational units. The Memphis State team wishes to take this opportunity to express its gratitude to these individuals and units not only for their support, but their positive contributions in terms of searching for reliable data. While not all individuals can be cited since the list is extensive, we wish to at least point out the most paramount contributions which aided us in preparing this study in a little over 60 days.

Foremost recognition should be given to those senior Naval leaders who have to make highly critical fiscal decisions concerning new training systems. Unlike weapons systems, the training components receive less fiscal support and far more scrutiny in terms of their contribution. Therefore, a commitment to a new approach especially without definitive cost justification represents a form of decision making of the highest magnitude. Therefore, we wish to recognize Vice Admiral James Wilson, Chief Naval Education and Training, and Rear Admiral A.M. Sackett, Chief Naval Technical Training. These individuals have been consistently supportive of the CMI effort within the Navy structure.

The genesis of this study is directly attributable to Captain Bruce Stone and Dr. Worth Scanland, members of Admiral Wilson s staff. Their keen interest and ardent enthusiasm for Navy CMI has led directly to this intensive effort. One can only trust that the substance of the study warrants their professional and personal commitment and integrity.

In turn, within the CNTECHTRA organization, Captain T.F. Mullane, Commander J. Davis, Norman Kerr, and Diana Mims were highly enthusiastic and informative in support of the study.

Captain J.L. Girard, Commanding Officer of the Naval Air Technical Training Center and his staff made invaluable contributions in terms of data collection and eventual interpretation of the true significance of the findings. Mr. Henry A. Edsall, Civilian Educational Specialist and Assistant to the Director of Training, NATTC, provided necessary liaison within the schools. Data collection was provided by Commander William A. McWaters, Jr., Officer-in-Charge of the Avionics Schools Group which includes Basic Electricity and Electronics, Commander R.L. Horton, Officer-in-Charge, Mechanical Schools Group which provided information from AFUN School and ADJ School, and Commander D.F. Fiene, Officer-in-Charge, Training Analysis.

There are also innumerable educational specialists, instructors, and curriculum developers within these schools and the NATTC, Memphis organization who deserve a great deal of credit. These are the individuals who have made Navy CMI what it is. Without their contribution the system would not be operating at its high level of impact. Being too numerous to name, one can only offer them the Navy salutary: "Well Done".

As a highly important counterpart, those individuals associated with the computer systems have been essential in the system development. These include but are not limited to Mr. Charles Tilly, Mr. Randy Woolley, Mr. Robert Potts, Mr. Ed Shye, Mr. Carl Weaver, and Mr. Fred Williams. These computer personnel were invaluable in retrieving learning data which so clearly documented the current capability and capacity of the CMI system.

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Finally, I wish to thank my many colleagues at Memphis State University as well as the institution itself for supporting this endeavor, especially in terms of releasing our time to pursue this activity. The University's commitment to working with all of its community members and especially NAS, Memphis is not to be underestimated. One can only look forward to additional studies of this type which represent a careful scrutiny and documentation of an ongoing large, human training system.

Duncan Hansen

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ABSTRACT

The Navy CMI system represents the most outstanding large computer based, individualized instructional system developed to date. There are several reasons for this important achievement. First and foremost, there has been and continues to be exemplary training effectiveness within the system. The logistic achievement of a computer supporting in excess of 3,000 students in multi-sites represents a first in this field. A more dramatic achievement is the cost beneficial outcome -- a savings of $10.2 million during FY 75, a savings rarely found in the initial life cycle of a training system. Finally, the Navy CMI system has enabled institutional integration of Navy technical training into common practices and styles while achieving its own unique benefits.

The development performance data yielded to date by the Navy CMI system provides a strong quantitative argument on its behalf. First the CMI system has yielded significant course reductions ranging from 24 to 30 percent with a mean of 48.6 percent. This has yielded a $10.1 million saving in student salaries. Second, the effective reduction in on-board students has allowed for an associated reduction of 23 percent in instructional/support personnel which has yielded savings of $1.7 million. Third, the CMI training approach yields significantly better end-of-course performance levels while the attitudes of students tend to be more positive. In turn, the CMI system has significantly lowered the attrition rate, to somewhere between 4.5 and 11.1 percent. This has yielded approximately $550,000 in savings for FY 75; this

should increase as the system is expanded. Finally, the computer implementation, as currently operating and in terms of the acquisition of the Honeywell system for expansion, has yielded savings in both the competitive procurement itself and the potential for expanded capability.

In terms of the institutional training processes, the CMI system has effectively integrated both personnel and operational procedures. For example, the learning center supervisors and ISD personnel, who are highly committed to CMI's implementation and operation, perceive its approach to individualizing the training process as most successful. The attitudes of the personnel involved are highly positive, thereby greatly benefiting the system's effective implementation and success.

The Navy system also represents an outstanding example of how an R&D activity culminated in fruition of an actual training operation. The research climate, shared civilian and uniformed personnel, a commitment to sound training design, and an adaptive approach to CMI systems goals undoubtedly allowed it to move from the R&D phase to fully operational status in less than a decade. Compared to the University of Illinois PLATO system and the Air Force Advanced Instructional System, Navy CMI is the largest and seems the natural candidate for both expansion and further elaboration in the future. While each of these three computer based systems has its own unique purposes, goals, and implementation characteristics, the Navy CMI system is yielding performance and cost benefits that are especially attractive in the mid '70's.

The future of the Navy CMI system is already designed. It shall grow to support 17,000 students by 1980. During the course of this study, new enhancements have been identified. Instructional strategies and instructional system development activities can give a sensible re-infusion of proven R&D prototypes which would be highly cost beneficial during the coming years. Thus, in a sense, this monograph ends where it begins; that is, in a realization that research and development can again contribute to this outstanding system which fortunately has been designed to infuse new ideas and concepts while maintaining its high cost beneficial impact.

THE NAVY CMI SYSTEM: CURRENT STATUS AND POTENTIAL

CHAPTER 1. Introduction to the Navy's CMI System

During the past half decade Navy technical training, especially within its air arm, has developed the largest computer based training system in the world. The basic purpose of this document is to provide a description of this CMI system to include its history and its future potential. A report has not been forthcoming due to the documentation concerning the Navy CMI system being embedded in various official reports. The purpose of this monograph is to provide a coherent description as reflected by the following objectives.

Study Objectives

1. To describe the current status of the Navy CMI system and to relate this to its R&D origins, its current climate, and its likely future evolution. The primary purpose is to describe the system, past, present, and future. This is considered crucial so that individuals can see that the system is growing not only in terms of numbers of computer components, but in terms of training sophistication and complexity. More importantly, the Navy CMI has had a climate, both R and D and operational, that has facilitated its adaptation and positive accomplishments.

2. To identify CMI training performance outcomes, as well as its cost benefit relationships for Navy Technical Training. To adequately assess a technologically based training system, one has to consider its

training performance outcomes -- learning rates, attrition rates, and general outcome performance levels. These, in turn, shall be related to the costs of the system, especially as compared with such alternatives as conventional instruction. In order to broaden the base for viewing the Navy CMI system, the purposes and operations of the Air Force Advanced Instructional System, Lowry Air Force Base and the PLATO CAI system at the University of Illinois, Champaign, Illinois shall be examined. The purpose of these comparisons is not to document that the Navy CMI system is the most cost-effective, since each of them has different types of goals, but rather to provide the reader with some understanding of how the Navy CMI system fits into the growing world of technologically based training systems.

3. To identify future Navy training alternatives which can be integrated within the CMI system. As indicated, the Navy is committed to allowing for both a growth in size of the system and, more importantly, an increase in its sophistication and complexity where appropriate. Appropriateness shall be judged primarily in terms of cost benefit relationships; thus, the Navy CMI system rejects no specific training strategem but rather views them all as components to be incorporated in the future for active pursuit of the most effective means of training its personnel. We turn now to a description of Navy CMI.

Navy CMI

CMI has been in the R&D process for several years. It is an ADP system which prescribes a course of study individually tailored to each student with emphasis placed on frequent testing and evaluation. The student in CMI systems does not, however, interact directly with the system as frequently as he would in other fully automated learning systems. The CMI system provides the student with lesson guides and assignments which lead him through individualized instructional modules which may utilize several media ranging from programmed instruction booklets to audio visual materials. Upon completion of a learning module the student is tested; the test is graded and the results are evaluated by the system. A product of this evaluation is additional lesson guides/assignments based on the student's test knowledge at that point. The student receives only the information necessary for satisfactory achievement at a prescribed level.

These CMI modules may be programmed at two or more levels of difficulty. In addition, instruction may be adapted to the individual requirements of students by three other means, namely, remedial loops within a module, repeating a module if it is not learned adequately the first time, and branching within a module in response to student answers at certain check points. It should be noted also that individualized instruction permits each student to progress through the course as rapidly as he can. This characteristic of individual pacing provides excellent opportunities for the use of incentives to encourage rapid achievement of training objectives.

At this stage of development in the application of the computer to Navy Technical Training, CMI gives promise of providing an economical and workable system. CMI is designed to provide cost effective education to a large number of trainees in the military environment where students train six to eight hours per day or multiples via double or triple shifts. Initially, eleven schools are being projected to utilize CMI; ultimately, twenty-four schools shall be involved (ultimate expansion has only network limits). These schools represent many varied disciplines but have some similarities. The schools normally consist of multiple classrooms. At Navy Memphis, these classrooms are housed in one-story wood frame buildings with approximately five classrooms per building. An average classroom will support approximately eighty students (range is thirty to one hundred). Within this context, classrooms will often be referred to as learning centers and a student's work area as his carrel. While assigned to his carrel, the student will perform various functions and assignments to include: reading texts, utilizing films and slides, performing lab experiments, taking tests, performing written assignments, and other learning procedures. During this learning process the student will normally have some questions that require instructor aid. He will also have many tests and written assignments that must be evaluated and scored. The student will also have to be directed to other assignments based on his previous responses. Scores will then have to be recorded and composites compiled.

CMI performs the functions of evaluating tests, scoring these tests, determining results, prescribing the next assignment, and recording and compiling grades. (This is further expanded in Chapter 4.) By putting these administrative and other tasks on the computer, the instructor is available to more students and has more time to aid each student.

CMI System Objectives

In more quantitative terms, the following objectives have been specified for the Navy CMI system: (1) an average reduction in the in-course time of students by 30 percent; (2) an average reduction in instructional/support staff by 20 percent; (3) an enhancement of end of course performance levels (this will be modest as there is only a small margin for possible improvement) and (4) a reduction in course attrition (rates of failure).

Structure of the Report

Given this basic understanding of CMI, we turn now to consider subsequent chapters of this report. Chapter 2 presents the history of the CMI system, especially in terms of its phasing from a R&D effort into an operational effort. Chapter 3 presents the data concerning student performance, especially in terms of progress rates, end of course performance rates, and associated attrition data, the prime objectives. Chapter 4 presents a description of CMI hardware and language -- past, present, and future. In addition, the characteristic of the CMI language (software programs) shall be described and critiqued. It should be noted that a very large computer procurement program has reached its conclusion while this report is being prepared. Chapter 5 presents instructor functions in CMI, especially those relating to roles and areas for possible additional contributions. Chapter 6 shall relate to the ISD course conversion process and associated management problems. Chapter 7 shall identify the cost benefits of the Navy CMI system. This will be performed primarily within the context of a comparison with conventional instruction, individualized managed instruction (a form of programmed instruction), and CMI. Chapter 8 shall present a context framework for large computer-based learning systems. Chapter 9 shall identify possible future potentials and alternatives for Navy CMI, especially those that appear likely to increase the cost beneficial effects. Chapter 10 shall provide a summary of the most significant findings yielded by this study.

CHAPTER 2. History of the Navy CMI System

The purpose of this chapter is to concisely describe the evolution of the Navy CMI system. The principal finding will emphasize how the CMI system phased through the research and development phase on into advanced development, and ultimately, into operation in less than a decade. To create, implement, test, and evaluate a system in less than a decade is an outstanding achievement considering the engineering and other technological environmental constraints of DOD. It is primarily for this purpose as well as for the edification of those who do not know where Navy CMI came from that this chapter has been prepared.

Early R&D Efforts

The historical antecedents to Navy CMI include: (1) the Teaching Machine and Programmed Instruction (PI) Movements of the late 1950's and early 1960's; (2) the early (1960's) multi-agency computer based instruction research exemplified by the ONR sponsored work at Stanford, Texas, Illinois, Pittsburg, MIT, Bolt, Baranek and Newman and many other organizations and educational research centers; (3) the establishment of the Navy Training Research Laboratory (NTRL) with a Branch Office at Memphis; (4) the mutually supporting interactions of ONR, NTRL, and the research staff of the Chief of Naval Air Technical Training, and (5) the establishment of the Advanced Development Objective for Education and Training (F-4303X).

The earliest precursor of CMI activities (1950's) can be traced to the contract support for programmed instruction research by Dr. Glenn Bryan, Office of Naval Research, to Dr. Douglas Mayo, Branch Chief for the Naval Training Research Laboratory (NTRL). This early programmed instruction research provided the conceptual framework as well as personnel for the development of CMI courses. During the early stages of the CMI project one could hardly discriminate between a programmed instruction course (PI) and a computer managed instruction course (CMI). CMI moved beyond this in a very short period of time.

The Office of Naval Research sponsored a training evaluational project at Washington University, St. Louis (Du Bois, et al, 1970) that provided a climate conducive for the development of the CMI system by placing young scientists at NAS Memphis. In a general sense, the efforts of Dr. Suppes at Stanford University, in looking at large student and data based drill and practice systems, was important. Also, the work of Professor Glaser of the University of Pittsburgh in looking at the integration of CMI within a public school setting allowed for the early identification of many of the testing logistic requirements. Although supported indirectly by ONR, these two were sponsored by civilian agencies. Finally, the ongoing CAI, CMI projects at Florida State University, sponsored by Project Themis, Department of Defense, and monitored by ONR contributed in a concurrent effort to evolving the efficacies of many of the proposed computer based training alternatives. While many other sources could be cited, it is evident that all of these efforts provide a climate for the training research and development of a clear understanding as to how the first CMI system should be assembled. This was obviously a critical first step in the phasing from R&D on into operation.

Advanced Development

In 1966, the Assistant Secretary of Defense for Manpower & Reserve allocated $70,000 to initiate the CMI project. The focus of this study was on individualization and funds were provided for both CMI implementation as well as computer assisted instruction (CAI) explorations.

The CMI project, as directed by Dr. Douglas Mayo, was initiated by the Chief of Naval Air Technical Training, Rear Admiral E. E. Christianson, at NAS, Millington, Tennessee in July, 1967. It was approved by the Chief of Naval Air Training and the Chief of Naval Operations. Subsequently, the Navy's advanced development objectives (43-03x personnel and training) provided the preponderance of funds through the direction of its Chief of Naval Personnel for the CMI project. Thus, the CMI project in its formal sense was initiated in fiscal year 1968 as a joint undertaking of the Chief of Naval Air Technical Training and the Navy Training Research Laboratory Branch Office, Memphis. It should be noted that Dr. Mayo held appointments in both of these units. Such cross appointments can be critical in the early stages of rapidly moving a system through R&D, advanced development, and on into operations.

By July, 1969, the development of the CMI instructional materials in the Aviation Mechanical Fundamentals School had progressed to the point that it was feasible to extend the CMI project to the Aviation Familiarization School. This course was an orientation to Naval Aviation taken by all trainees ordered to the Naval Air Technical Training Center, Memphis from the Recruit Training Commands. This amounted to an input of approximately 500 trainees per week. The present course was two weeks in length (originally six weeks) yielding an average time reduction under conditions of CMI of 2/3 or 67 per cent.

Joint Institutional Development

As is common to training research, a joint institutional development was pursued. Mr. Bernard of IBM prepared the first concept paper that lead to a contract with State Technical Institute of Memphis. The Memphis State University Computing Center developed the computer software that supports the CMI system. In so doing, they used an IBM 360, Model 40 computer with an IBM 2780 terminal. This terminal is a relatively high speed input-output device, which can direct the learning activities of a much larger number of students than can be handled by a typical teletypewriter terminal.

Under a separate contract, the Bureau of Educational Research and Services at Memphis State University supported the project with research pertaining to media selection and with assistance in preparing and coding instructional CMI materials.

The University of Tennessee Biometric Computer Center adapted a relatively new CAI language, called Coursewriter III, to the CAI requirements of the project before the language was released for general use. In addition, during the initial contract with the University of Tennessee, several hours of tutorial CAI instructional material pertaining to the Navy 3-M system were developed and tested. This work involved an IBM 360 Model 40 computer with a terminal, IBM 1050V. This terminal consists of a teletypewriter and has a random access slide and audio tape capability. Subsequent to the initial contract, the

Biometric Computer Center continued to supplement the project in-house CAI capability, as needed, with a remote terminal located aboard the Naval Air Station. The findings from this research indicated that CAI should be delayed for implementation within CMI. Such early investigations allowed for greater competence in pursuing the test sheet oriented CMI terminal (which is a compromise CAI terminal) than that typically found in larger remote batch terminals in CMI. Thus, Dr. Douglas Mayo and Dr. Larry Harding led the CMI system into its documentable state which provided enough evidence to allow for authorization and funding as an operational resource for CNTT. Dr. Kirk Johnson assumed the responsibility for basic research within the project. It should also be noted that their research and that of their colleagues (Charles Tilly and Chief Petty Officer O'Neil) provided extensive evidence concerning how appropriate CMI re-designs could be pursued. Additionally, Mr. Robert Potts provided the first file structure design for the system.

CMI Personnel

Within this project, the mix of civilian and uniformed personnel types was quite facilitating. First, there were the civilian training researchers as represented by Dr. Douglas Mayo, Dr. Larry Harding and Dr. Kirk Johnson, Dr. Johnson fostered the research to action interface. Dr. Harding, Stuart Carson, and Phillis Salop were responsible for the CMI developmental work (Naval Training Research Laboratory). Perhaps, more importantly, Mr. Charles Tilly, Mr. Robert Potts, and associates, civil servants within the computer support world of the Navy, assisted in the ultimate implementation of both the advanced development and the operational computer system. In reference to the conversion of instructional material, there were both civilians, primarily from Memphis State University, and Navy personnel. Some of these Navy ISD specialists continue to contribute at this time; continuity of this kind is invaluable.

Operational System

CNATECHTRA submitted an interim report on 26 October 1970 seeking approval of the CMI system as an operational element within Navy training. The Chief of Naval Air Training and CNET approved this action and advocated the CMI system to higher command levels. Captain Bruce Stone and Dr. Worth Scanland sponsored the computer based cost effectiveness simulation (CMI became cost beneficial after N> 1300) and formulated the basic rationale for the decision to go operational. This was approved by the CNO on 5 February 1971. The cost justification data clearly indicated the advanced evolution of this CMI system. (See Chapter 7.) A brief summary of this data should convince the reader.

Like industry, but unlike universities and public schools, the armed forces pay their students to undergo training, that is, they continue to pay the students' salaries while they are in training status. Time saved through more efficient training procedures permits an increase in productive manpower in operating units, or reduced overall manpower requirements without reducing the number of personnel in operational units. Certain facility and material costs often accompany reduction in course lengths, but only personnel costs are included in the present figures. The following two paragraphs describe the cost avoidance feature as envisioned at that time.

The reduction in average course length that is expected, for example, for the Aviation Fundamental Course is, for example, from six weeks to two weeks and for the Mechanical Fundamentals Course, from three weeks to two weeks. (These two courses are currently combined into one, AFAM.) This results in annual savings of 500 man years and 175 man years, respectively. At an average salary for pay grade E-3 of $3520 per year, this comes to $2,376,000. To this figure should be added the salaries of 32 instructors who will not be needed in the shortened courses. At $7,460, the average salary of pay grade E-8, this saving comes to $238,720. Summing the student saving and the instructor savings, we have a total gross saving of $2,614,720 per year.

The hardware required for the CMI system should cost about $336,000 per year if leased and installed at the Naval Air Station, Memphis (see Chapter 4). Computer operating personnel costs would approximate $130,500 per year. When the hardware and personnel costs are added to the $12,000 per year for supplies and miscellaneous expenses is added to the total cost comes to $478,500 per year. Subtracting this cost from the gross savings of $2,614,720, results in an estimated net annual saving of something over $2,000,000. The above figures were utilized for the initial justification to the CNO.

Computer hardware and operating personnel requirements for CMI and other ADP applications were set forth in the CNATECHTRA Command/Management Information System plan submitted to the Chief of Naval Air Training on 28 May 1970 and subsequently forwarded to the Chief of Naval Operations. This plan included installation of ADP equipment at the Naval Air Station, Memphis on 1 July 1975, capable of handling CMI requirements.

However, subsequent efforts to gain resource (fiscal) support for operationalizing and expanding the system were unsuccessful at the CNO/OSD levels because of the misconceptions at those levels of the applications of computers to training. On a succeeding occasion for the presentation of arguments in support of ADP equipment for the CMI operationalization, the CNET sponsor, Dr. Worth Scanland, presented to the CNO/OSD reviewers the position that the management of high student density individualized instruction created such large requirements for information and data processing that the only way in which such individualization was possible was through the application of modern ADP techniques. Couched in these terms, the requirement for ADP support could be defended in the same context as other ADP requirements, rather than in the context of an instructional mediating device. The resources were approved with no further delays, and the long process of ADP equipment acquisition was able to commence.

Finally, the course conversion took place in the Basic Electronic and Electricity School, Navy personnel along with Mr. Charles Tilly, provided for a significant re-design in the terminal equipment for the learning centers. This use of sheet oriented test op-scanning devices, a CRT, and a low cost impact printer has contributed invaluably to the smooth operation and growth of this system as well as its enhanced cost effectiveness.

As originally designed by the R and D group, a remote batch terminal (high speed card reader and line printer) was utilized by having human messengers from each center. The cost, time delays, and tendency for queuing from this configuration was unsatisfactory. The Tilly proposed terminal configuration resolved these problems and enhanced the system response time by smoothing the input distribution.

Conclusions

1. The Navy CMI system is an outstanding example of how training research and development can be brought to fruition in actual training operations in less than a decade. This was immeasurably aided by the research climate, shared personnel, rejection of unproven training alternatives, and a commitment to the CMI system goals.

2. The mix of civilian research psychologists (primary managers), Navy personnel, and university personnel provided the richness and critical mass so necessary to the design, validation and operation of a system.

3. The CMI research effort yield three immediate outcomes: (1) a prototype CMI system that required further design, (2) a delay in CAI implementation until cost justifiable, and (3) a significant reduction in course training time that justified moving into operations. Obviously, appropriate research can be initiated at any time.

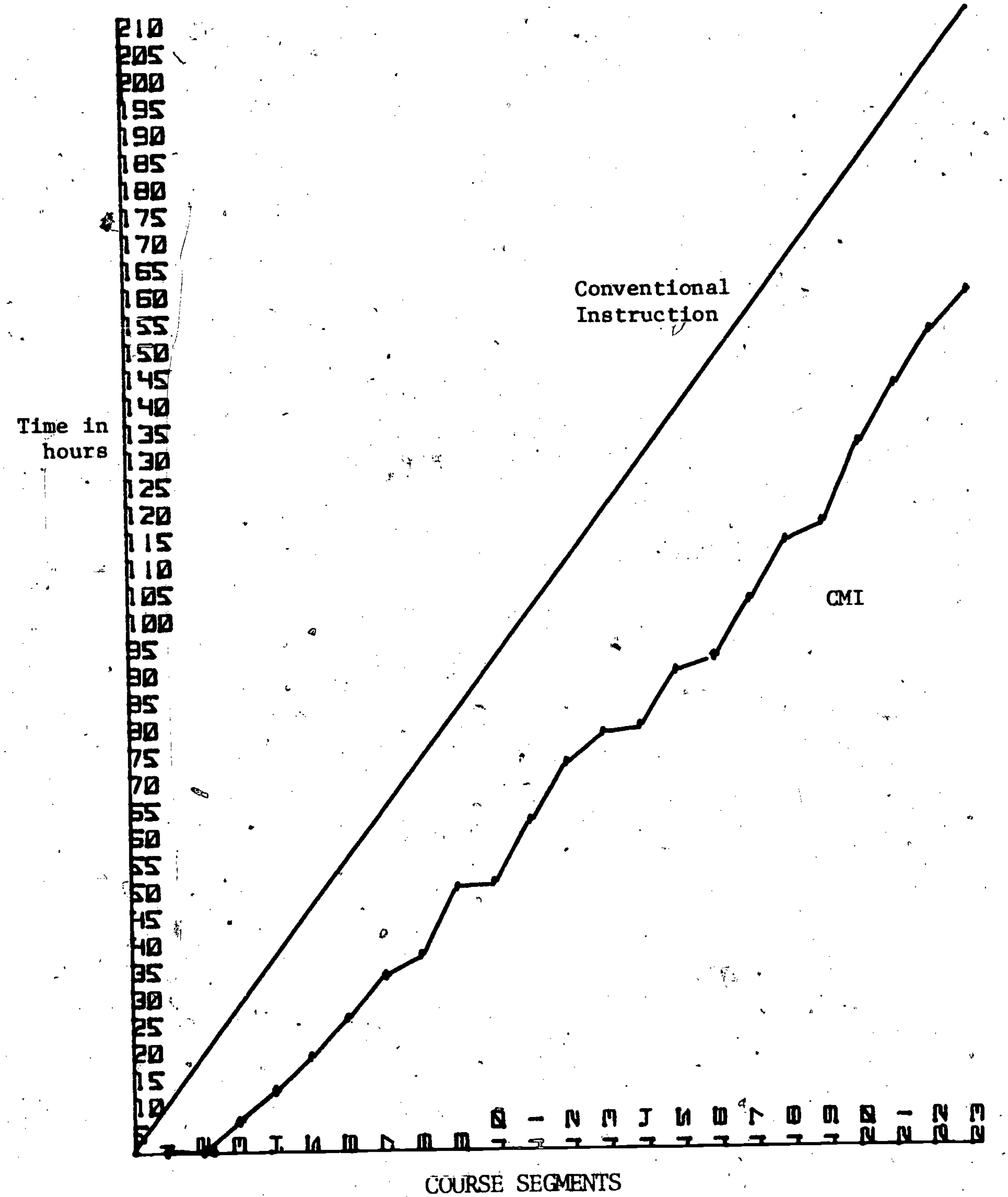
CHAPTER 3. Student Performance In Navy CMI

As indicated in the introduction to this monograph, there are two principal objectives for the Navy CMI system. These are (1) a 30 percent reduction in training time for students and (2) a 20 percent reduction in instructor/support personnel requirements. As corollary objectives, there is the intent (3) to improve the level of end of course mastery and for (4) a reduction in course attrition or student failures. Each of these objectives shall be reviewed in terms of current available data. These data were gathered during the last 30 days from the CMI system as well as from prior studies which were completed within the last 12 months.

Time in Course

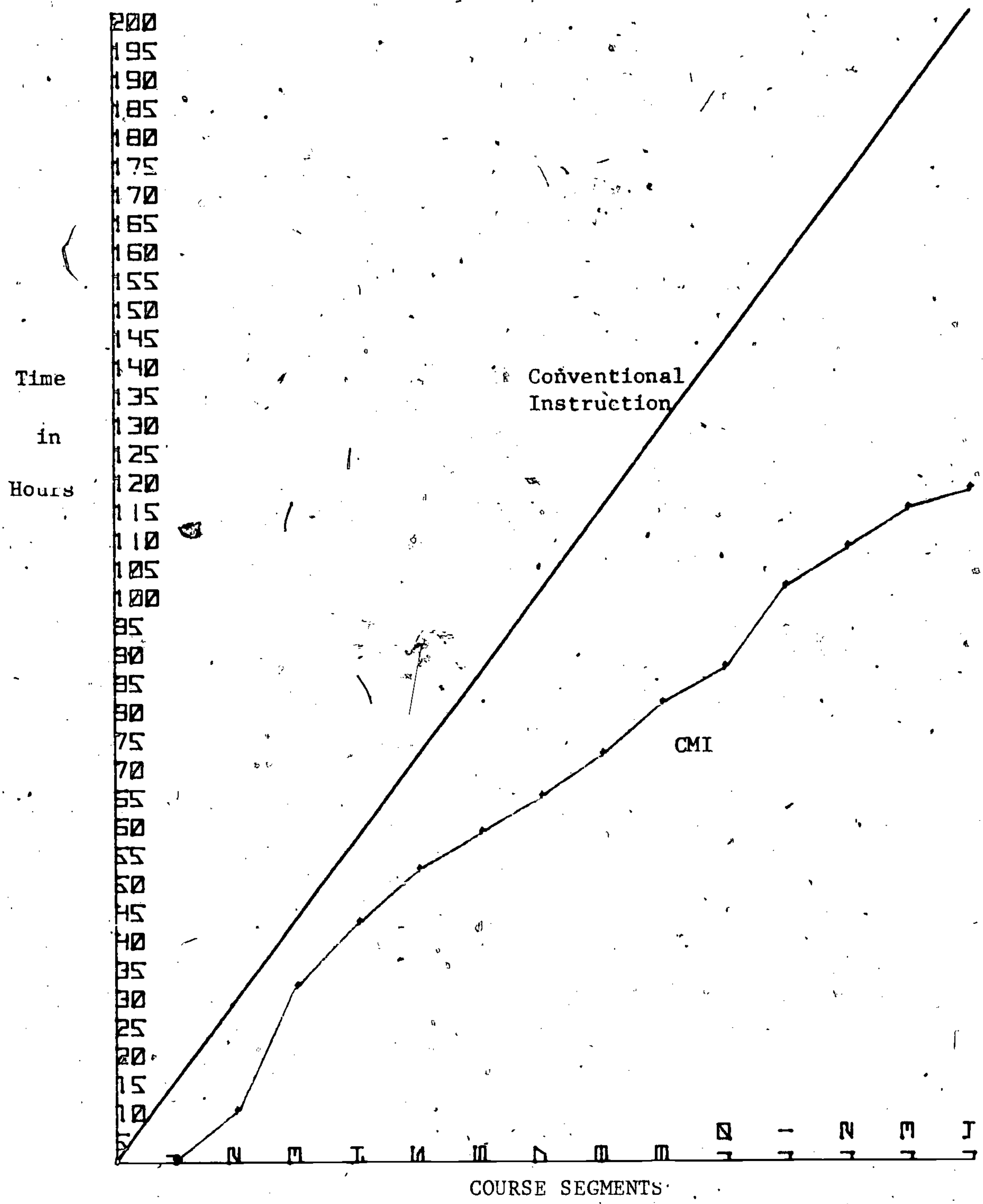
The data of three CMI courses currently in operation came from three sources: (1) currently enrolled students (early April, 1975), (2) cumulative data from the July-December, 1974 period, and (3) comparative data on an experimental study at Great Lakes ("Formative Evaluation of An Experimental BE/E Program," Fishburne and Mims, March, 1975). There are three courses that contribute data: (1) Basic Electronics and Electricity (BE/E), (2) Aviation Fundamentals (AFUN), and (3) Aviation Mechanics Jet (ADJ). (Tables and Figures shall indicate these groups appropriately.)

For the three courses, Figures 3.1, 3.2, and 3.3 present a comparison of the CMI mean accumulative time per module as contrasted with the prior fixed conventional instruction time. (The time for the CI course units has been smoothed as to minor unit to unit variations.)



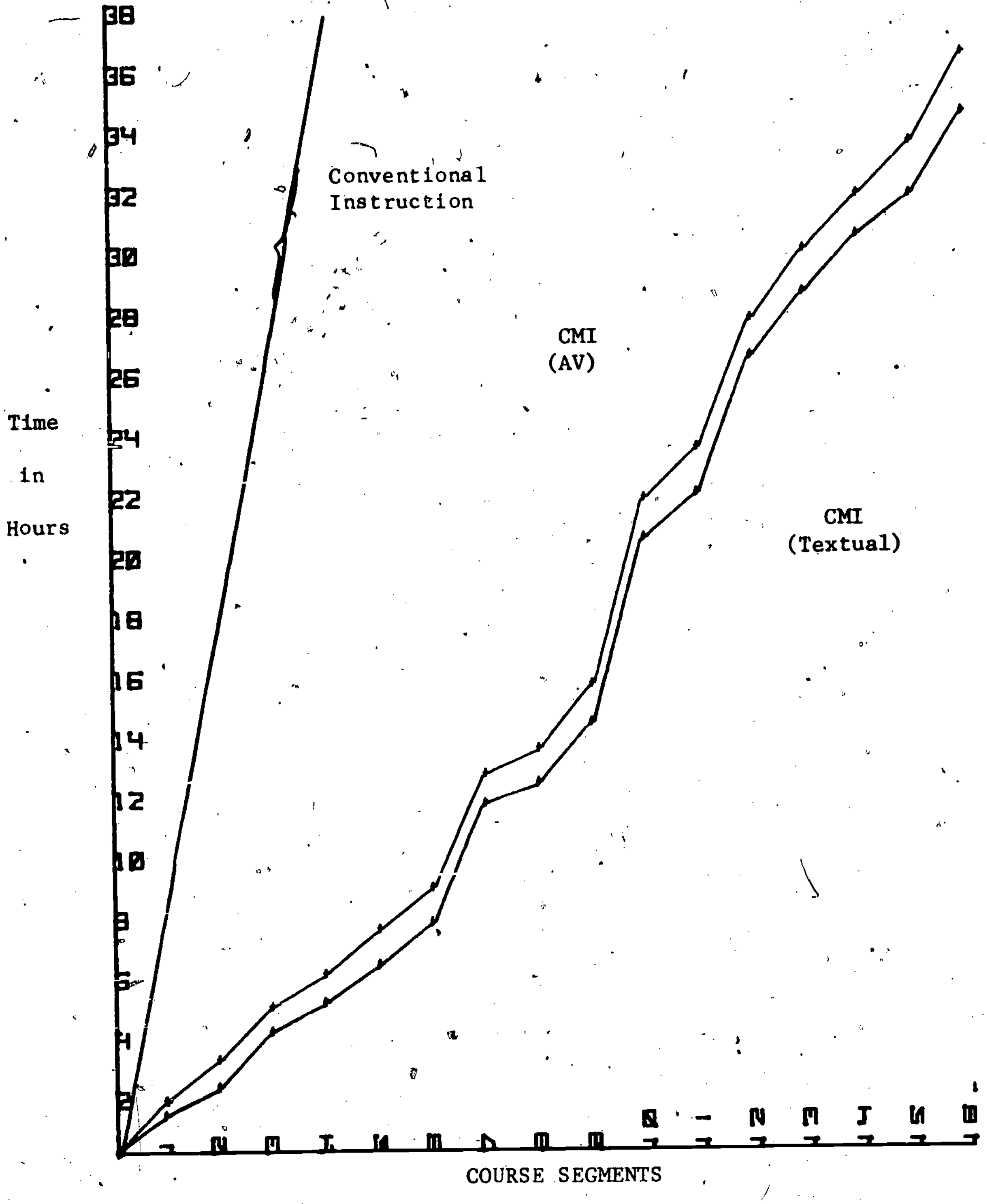
Mean Learning Completion Time for BE/E

Figure 3.1



Mean Learning Completion Time for ADJ

Figure 3.2



Mean Learning Completion Time for AFUN

*Conventional Instruction = 180 hours

Figure 3.3

As indicated in Figure 3.1, student progress time through the CMI BE/E course is significantly and progressively less than that of the conventionally taught BE/E course. (The computer module numbers are not exactly equivalent to the content units due to segmentation of large content units and large exams.) Notice that the final segment of the CMI BE/E course is completed at 159.3 hours, while the conventional instruction is completed at 210 hours. While the absence of identical instructional segments prevents a module by module comparison of the two versions of the BE/E course, the projected linear relationship of the conventional instruction serves to illustrate the contrast with CMI. Likewise, this relationship in much greater contrast is shown for representative tracks of the ADJ and AFUN courses in Figures 3.2 and 3.3. This illustrates that there shall be a range of course time reductions that center somewhere between 35 and 45 percent.

For more detailed within-course outcomes, a contrast of a textual (reading) only treatment, as opposed to an audio-visual training treatment within the AFUN course is also presented in Figure 3.3. As is commonly found, the reading course version is slightly faster. For the brighter students, textual versions of a CMI course are undoubtedly the best. Audio visuals have a place for the lower category learner and for those performance skills requiring visual demonstration.

Table 3.1 presents these percentage time savings in quantitative form. Obviously, a statistical test is not required to confirm the significant superiority of the CMI group.

Given the nature of the samples (all course samples exceed 3000 students) and the consistency across courses, CMI is obviously achieving its planned objective of a 30 percent course reduction.

Table 3.1

Mean Course Time Savings Via CMI

Course	Conventional Instruction Time	CMI Time	Percent Reduction
BE/E	210 hrs.	159.3 hrs.	24.1%
AFUN	180 hrs.	35.45 hrs.	80.31%
ADJ	198 hrs.	118.2 hrs.	31.0%
Mean Total	196 hrs.	104.3 hrs.	46.8%

Table 3.2

NUMBER OF INSTRUCTOR BILLETS FOR FY 72 - 74

Billet Description	FY 72	FY 73	FY 74	
ADJ - NATTC Memphis				
Authorized	69	64 (7.3%)	55 (14.1%)	
On-board	66	66 (0%)	55 (16.7%)	
AFUN - NATTC Memphis				
Authorized	116	98 (15.5%)	77 (21.4%)	
On-board	134	96 (28.4%)	92 (4.0%)	

*Figures in parentheses indicate percent reduction from previous year.

Instructor/Support Personnel Requirements

Table 3.2 presents the authorized and on-board numbers of instructor billets at two NATTC Memphis schools transitioning into the CMI system from FY 72 - FY 74. It is apparent that significant reduction occurs as CMI progresses in these schools. Starting with the baseline non-computer managed ADJ course in FY 72, Table 3.2 reveals a 7.3 percent authorized reduction for FY 73 and a 14.1 percent authorized reduction for FY 74. This total authorized reduction of 21.4 percent is approximated by the 16.7 percent on-board reduction actually achieved. Likewise, the AFUN course experienced a 15.5 percent authorized instructor billet reduction in FY 73 and a 21.4 percent reduction in FY 74. The total on-board reduction actually achieved for this period was 32.4 percent.

Due to the creation of the BE/E course from portions of previous "A" school courses, transitional figures showing progressive billet reductions are not completely available. The BE/E course did, however, achieve a 16.1 percent reduction on on-board instructor billets for FY 74. For the two year interval, this probably approximates 20 per cent instructor course reduction. This can be observationally verified in that existing IMI courses require six instructors for a section of students (N = 80) while CMI functions with only three instructors. In some cases, the surplus instructors have been assigned to future CMI conversion functions rather than being transferred off-base.

In terms of the second objective, there is a 23 percent overall reduction in instructor personnel. As to be discussed in Chapter 7, this yields a significant reduction in support personnel. It should be noted that a return to conventional instruction would immediately increase the budget for staff by 35 percent, a highly significant factor.

Students Under Instruction

Figure 3.4 depicts the weekly load of students under instruction from July 1974 through January 1975 (excluding Christmas week) for the BE/E, ADJ, and AFUN CMI courses. While the growth from a total student load of 1698 in the first week to 2902 in the twenty-eighth week is impressive, the fluctuations from week to week are also of significance. Obviously, the system is extremely flexible in its capability. The transition from a student load of 2160 during the twenty-sixth week to 2843 in the twenty-seventh week is particularly impressive. There are no other examples of a computer based training system that allows for expansion factors like this one. The logistic problems (e.g., student registration) and orientation requirements have tended to constrain these computer systems. This evidence supports the observation that CMI's most immediate beneficial contribution is in school house administrative requirements.

Levels of Learning Mastery

While extensive comparative data are unavailable due to the absence of detailed records from the conventional courses, the Great Lakes Study (Fishburne and Mims, 1975) plus FY 75 accumulative BE/E data can be reviewed and composed. Table 3.3 presents results for the performance level on the first attempt at the final comprehensive test (all students are ultimately remediated to the 100 percent level) by conventional

Figure 3.4

Total Student Load for
BE/E, ADJ, and AFUN CMI Courses

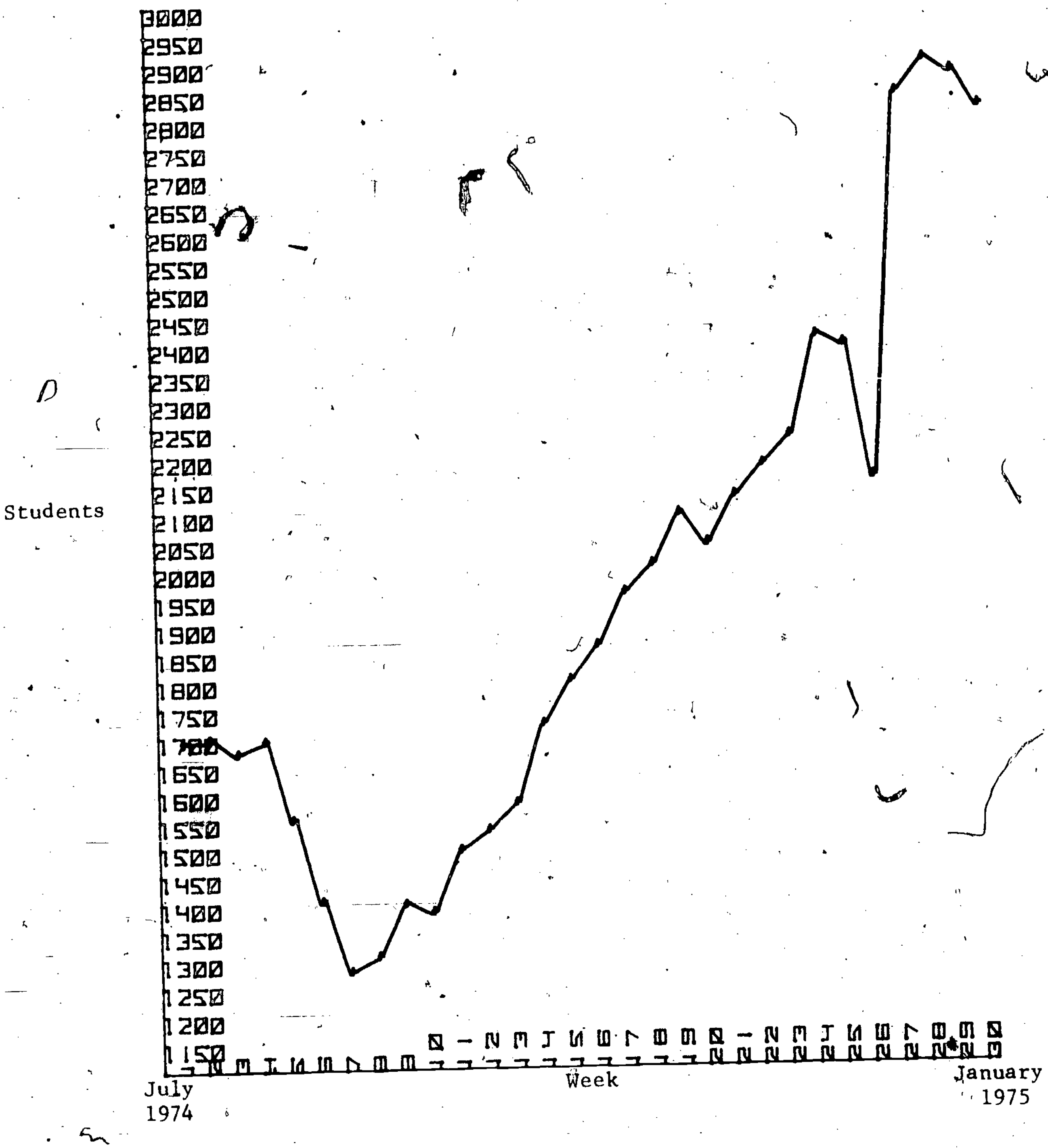


Table 3.3

Mean BE/E Mastery Performance Levels and Completion Times For Conventional Instruction, IMI, and CMI Groups

Instructional Type	N	Mean Scores For 1st Pass on Final Comprehensive Test*	Mean Completion Times (Hours)
CI	50	79.30	214.68
IMI	50	77.69	163.62
CMI	1556	82.73	152.47

* 100 = perfect score

Table 3.4

Mean Error Rates on Module Tests for AFUN Course

Module No.	# of Items	x̄ (Textual) %	x̄ (AV) %
1	39	2.54	3.74
2	31	1.71	1.69
3	16	2.12	2.37
4	31	1.60	1.64
5	48	.98	1.19
6	39	1.04	1.33
7	47	5.16	4.84
8	27	.38	.35
9	22	2.07	2.54
10	41	5.33	4.76
11	50	.84	.92
12	25	1.51	1.53
13	43	1.45	1.74
14	25	.72	.44
15	39	2.51	2.83
16	45	3.29	3.47

instruction, instructor managed instruction (IMI is a form of programmed instruction), and CMI. As presented, the CMI group is superior in learning performance levels (only students who were qualified for "A" School are included) plus requiring less learning time.

In turn, Table 3.4 presents mean error percentages for module tests in AFUN. These mean error rates indicate that CMI is exceeding a 90 percent performance rate. Considering these data plus the comparative instructional approach data, CMI consistently yields superior learning as demonstrated on the mastery tests.

Course Attrition

Unfortunately, CMI as opposed to CI training attrition data is unavailable in a comparable form. Since NAS Memphis is the only user of CMI for the BE/E course up to January, 1975, the attrition data for the last half of FY 74 compare Instructor Managed Instruction (IMI) at San Diego and Great Lakes with CMI treatments at Memphis. Table 3.5 presents the attrition data by location, attrition type (academic vs. non-academic), and mental groups, I - IV. Obviously, the CMI yields highly significant lower attrition rates (for these sample sizes, a difference of one percent is significant beyond the P less than .01 level). The percentage of reduction achieved by CMI ranges from 4.5 percent to 11.1 percent. These reductions are both statistically significant and, more importantly, system significant in cost plus manpower terms.

General Observations

In the development of instructional technology and computer based

Table 3.5

BE/E SCHOOL ATTRITION
(Jan-Jul 1974)

	Great Lakes IMI	Memphis CMI	San Diego IMI
Percent Flow (Sample Size)	2989	3210	2579
OVERALL ATTRITION	17.9*	6.8*	11.3*
School Academic Attrition	9.6	2.2	9.8
School Non-Academic Attrition	8.3	4.6	1.5
School MG I and II Attrition	5.7	3.5	3.8
School MG III Attrition	9.9	2.4	7.2
School MG IV Attrition	1.2	.4	.3
School MG Unknown Attrition	1.1	.5	.8

*All attrition statistics are percentages of the total student flow.

systems, there are no other examples like the Navy CMI System in terms of initial achievement of system objectives. Obviously, the cost benefit implications are highly positive. To return to a conventional instruction approach would be exceedingly costly to the Navy. Given this two-year performance period in which all objectives have been attained or exceeded, future expansion could be even more cost beneficial to the Navy.

Conclusions

1. CMI yields significant reduction in course instructional length, varying from a 24 percent to 80 percent reduction. The CMI goal of a 30 percent reduction is obviously attainable. Even greater savings can be achieved given new training alternatives for CMI.

2. The 20 percent reduction in instructor/support personnel is being achieved--the actual reduction being 23 percent.

3. CMI yields significantly better end-of-course performance levels, and the attitudes of the students tend to be more positive (see Chapter 5).

4. CMI yields significantly lower attrition rates--approximately 4.5 to 11.1 percent in magnitude.

5. The Navy CMI system is unique in the early achievement of its objectives; in fact, the achievements tend to exceed the objectives.

CHAPTER 4. Navy CMI Hardware and Software Language

This description shall cover both the current and future (procurement completed) CMI configuration. The description of the coming system will reflect both the hardware and software to be installed at NAS, Memphis. In turn, using a combination of contractor and Navy personnel, the CMI language has and shall have to undergo certain fundamental changes both for conversion and efficiency reasons. All future modifications shall be made by Navy personnel. The focus of this chapter shall stress technical aspects of the current and future systems with some insights into the planning/procurement process. (The non-technical reader may wish to branch around this chapter.)

4.1 Present Hardware Configuration

The new Navy computer system will replace all computer and communication capabilities currently under service contract through Memphis State University. This includes the central computer, an XDS Sigma 9, located on the MSU campus and terminal equipment, both the administrative RBTs and classroom clusters installed at NATTC, Memphis, NTC, Great Lakes, and NTC, San Diego. The equipment to be replaced is documented in detail as follows:

Central Computer

1-8610E Sigma 9 System w/128K words

1-8665E Port Expansion

1-8675 MIOP Channel B

2-8671 Four Byte Interface

1-7012 Keyboard/Printer

1-7122 Card Reader, 400 CPM

1-7231 RAD Controller

1-7232 RAD Unit, 6.2 MB

1-8680 High Speed RAD IOP

1-7212 RAD Unit, 5.3 MB

2-7240 Disc Controller

2-7241 Extended Width Interface

2-724B Disk Storage, Four-Spindle, 200 MB

1-7315 Tap Controller + 1 Drive

1-7315 Magnetic Tape Unit

1-7446 Line Printer, 1500 LPM

1-7630 Communications Controller Plus 8 Lines

3-7631 Eight-Line Expansion Units

5-7601 Data Set Controllers

5-7602 Full Duplex Features

Terminal Equipment

(1) Classroom Clusters

24-OPSCAN 17 Scanners

24-CDC 713-10 CRTs

24-CDC 713-120 Printers

(2) Administrative Terminals

3-DATA 100 Model 74 RBTs

2-IBM System 7/IBM 3780 Printer/Card Reader subsystems

(3) Data Entry Terminals

2-CDC 713 CRT

Communication

24-300 BAUD dedicated, unswitched full duplex lines with Bell Telephone 113 modems at each end of the line.

5-4800 BAUD dedicated, unswitched, C-2 conditioned, full duplex lines with 4800 BAUD Bell Telephone modems at the ends. Frequency division multiplexors are used for the line to NTC Great Lakes and NTC San Diego.

It should be noted that the ratio of students to this equipment is approximately 70 to 1. It can, in fact, grow to 80 to 1 as represented by the classroom clusters. Such a student to equipment ratio is most advantageous and is undoubtedly the clearest indicator of the type of system being utilized by the Navy.

4.2 New Navy CMI Configuration

To facilitate the high level of system effectiveness required by the CMI system, computer manufacturers participating in the procurement were required to design a configuration which contained, as a minimum, two central processing units for reliability reasons. Both processors are individually capable of processing all application programs and able to address all storage devices, remote terminals, input/output units, other peripheral devices, and modules of central memory. Availability rate (up time) for the central site system was set at 95 percent of the scheduled time in a given month. This performance requirement was established not only for the 30 day acceptance period, but Honeywell, the successful vendor, must maintain this level of performance throughout the systems life (6 years). Failure to meet this availability requirement will entitle the Government to collect credits for systems downtime (one percent of the installed systems total monthly charge for each percent over five percent).

The new CMI system is so configured that no device will, when down, render the central system incapable of supporting the interactive process between the student and the computer for a period longer than 10 minutes. The system will, at all times, include a minimum of two disk (immediate access storage) controllers each of which is accessible by both processors. This gives the capability to access any disk file through alternate paths in the event any one of the controllers becomes inoperative.

Presented in Table 4-1 is the central site configuration scheduled for installation at NAS, Memphis. Note the dual CPU's system controllers, memory, input/output multiplexors, disk controllers, system consoles, and datanet communication processors. Configurations with more than one of any module not only increase throughput, but also provide built-in backup. And if a portion of the system does go down, Honeywell's General Comprehensive Operating System (GCOS) allows the user to quickly reconfigure the system to work around the failed module or peripheral and keep serving the Navy schools.

The front-end network processors (datanets) see to it that the communications network remains available also. Their own stand-alone operating systems not only give better service to the users by removing the overhead of data manipulation from the central system but protect against system downtime by continuing to perform many tasks even when the central system is down (a form of centralized and local processing combined). If the system, however, should go down, automatic restart

Table 4-1

Initial Central Site Equipment List

Quantity	Model No.	Description
2	CPS 6202	Central Processor System, 131,072 36-bit words memory
2	MSP 0600	IAS Disk Processors
8	MSU 0400	Removable IAS Units, 117 million characters each
1	MTP 0600	Magnetic Tape Processor
4	MTU 0500	Nine-Track, 800/1600 CPI Tape Unit
1	MTU 0400	Seven-Track, 556/800 CPI Tape Unit
1	URP 0601	Peripheral Controller
1	PRU 1200	Printer, 1200 LPM
1	CRU 1050	Card Recorder, 1050 CPM
1	CPZ 0201	Card Punch, 300 CPM
2	CSU 6001	Console
2	DCP 6632	Datanet Front-end Processor

and recovery features guard against lost information. The central host system is presented schematically in Figure 4-1.

At the remote training sites, message concentrators will be installed to concentrate classroom cluster and administrative terminal traffic. The message concentrator proposed by Honeywell is a multi-function system. It is configured to handle the combined functions of the administrative terminal and the remote concentrator concurrently. It will receive and validate messages and store and forward message traffic between the administrative terminals, classroom clusters, and the Memphis host computer. This message concentrator provides for complete accountability for traffic in and out of the concentrator, retransmission and alternate routing of input/output transactions, and retrieval of previously received messages. In the event of central processors failure, or failure of the communication lines to the central site, the concentrator will be capable of receiving messages from the classroom clusters and the administrative terminal without interruption or delay. The message concentrators will be linked to the host computer over dedicated 9600 bps lines, with 4800 bps dial-up as backup. As shown in Figure 4-2 the remote sites have also been configured to provide maximum availability. Dual concentrators are connected via switching units that allow all classroom clusters to be switched to another concentrator in the case of a concentrator failure. All administrative terminals have a primary and alternate route to separate concentrators. Communication paths on the host side of the concentrators are configured so that they are always provided a route to the host computer.

Figure 4-1

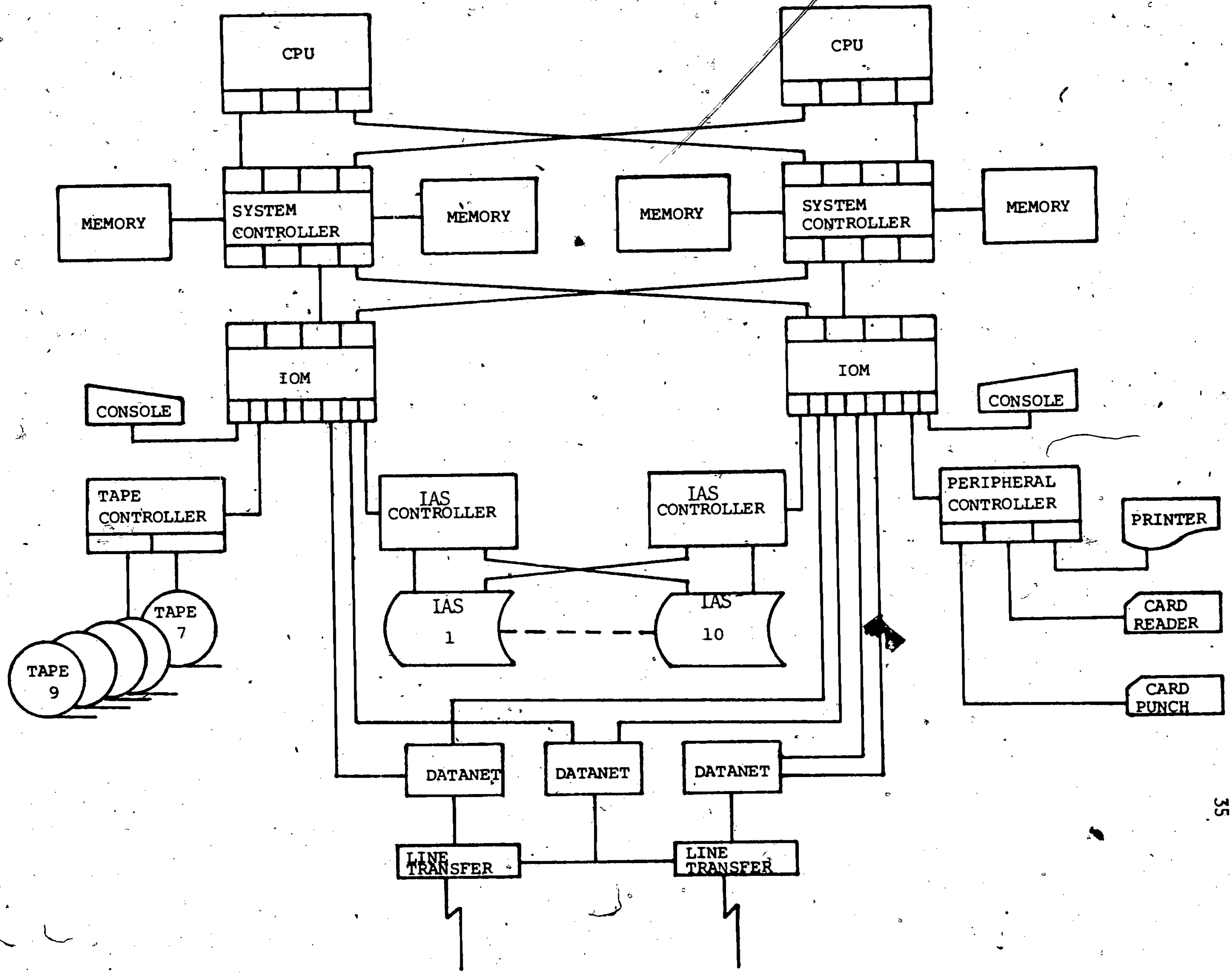
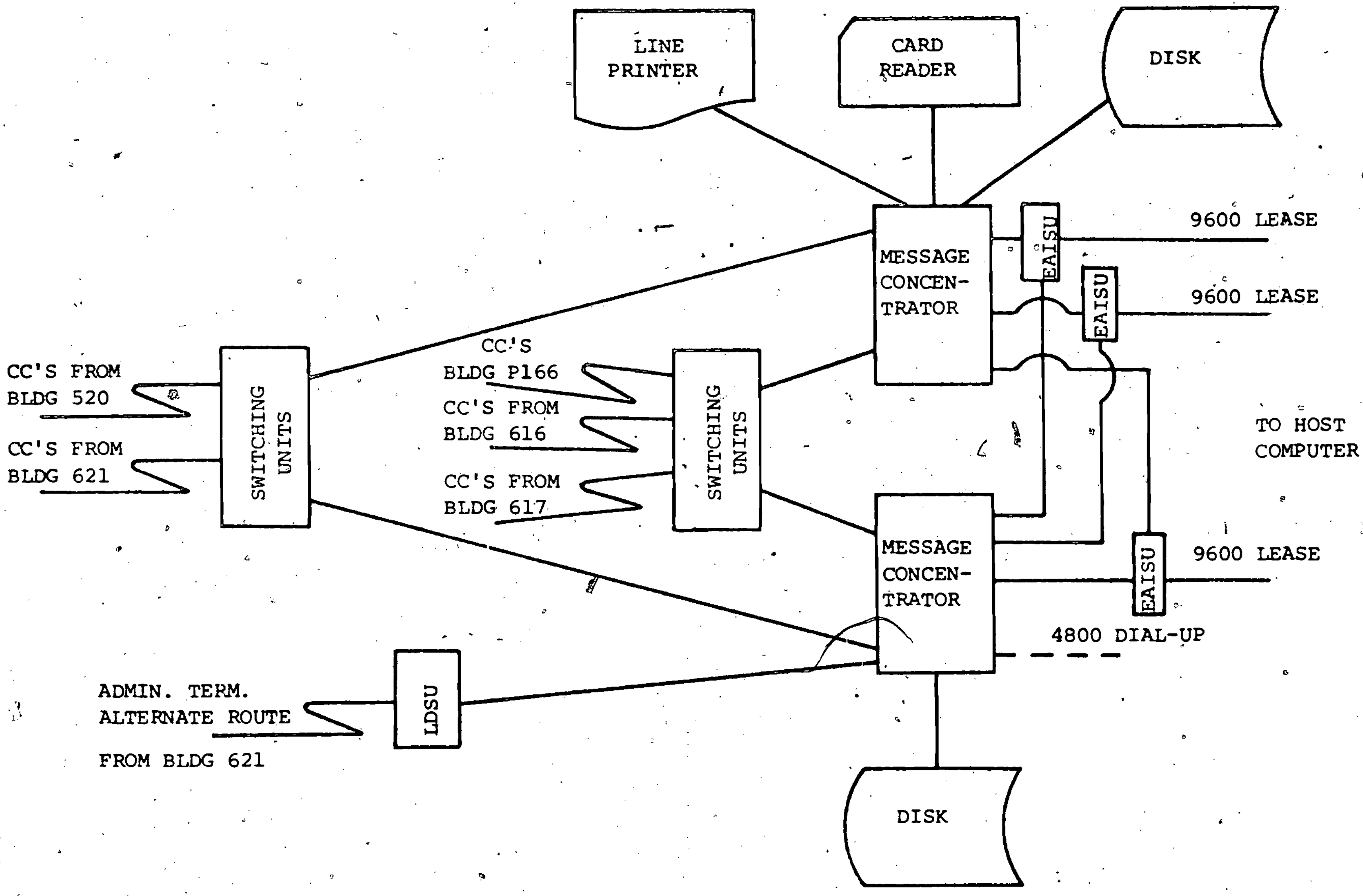

CPU
CPU
SYSTEM CONTROLLER
SYSTEM CONTROLLER
MEMORY
MEMORY
MEMORY
MEMORY
IOM
IOM
CONSOLE
CONSOLE
TAPE CONTROLLER
TAPE 7
TAPE 9
IAS CONTROLLER
IAS CONTROLLER
IAS 1
IAS 10
PERIPHERAL CONTROLLER
PRINTER
CARD READER
CARD PUNCH
DATANET
DATANET
DATANET
LINE TRANSFER
LINE TRANSFER

Figure 4-2
REMOTE CONCENTRATION SITE



NTC GREAT LAKES
BLDG P-166

At Memphis, all terminal clusters and administrative terminals are interfaced directly to the host computer via common carrier communication lines.

To give a portrait of the CMI system size within Navy training (See Chapter 7 for further details), Table 4-2 presents the classroom terminal schedule by fiscal years, and Table 4-3 presents the administrative terminal schedule. One can observe that the significant build-up will take place by FY 78.

Another facet to the system availability is the engineering technology employed in the design, manufacturing, and maintenance program of the system put together to meet the stringent requirements of CMI. With Honeywell's Series 60 computer having the latest advanced technology incorporated into its design concepts, it will ensure high uptime. For example, error detection and correction logic in main memory provides a high degree of data accuracy. While processing is being done, online testing programs will check all portions of the system. Automatic error analysis and logging programs will provide fast diagnostic reports, thus pinpointing potential trouble spots and avoiding unnecessary interruptions. On-site maintenance support will also be available at the Memphis site throughout the training day. These and other items all add up to the reliability needed to successfully implement CMI. In short, the Training Command can be assured of dependable performance because the CMI computer system was designed for maximum availability.

The Series 60 computer acquired from Honeywell for the continued support of CMI is a Series 60 large scale Level 66 computer components.

Table 4-2

Classroom Cluster*

Installation Schedule

	FY 76	77	78	79	80
NATTC Memphis	29	52	73	73	73
NTC San Diego	8	27	37	37	37
NTC Great Lakes	28	66	79	84	84
NTC Orlando		16	16	16	16
NTTC Meridian				21	21
Total	65	161	205	231	231

*Each classroom cluster consists of one Honeywell Model No. TN 1200 12C CPS Keyboard/Printer and an OPSCAN Table Top Scanner (300 sheets per minute).

Table 4-3

Administrative Terminals*

Installation Schedule

	FY 76	77	78	79	80
NATTC Memphis	3	4	6	6	6
NTC San Diego	1	3	3	3	3
NTC Great Lakes	2	3	4	5	5
NTC Orlando	0	1	1	1	1
NTTC Meridian	0	0	0	1	1
Total	6	11	14	16	16

*Administrative terminals proposed for the remote sites are all Honeywell Model No. RCP707 Multifunction terminal, peripheral, message switching subsystems equipped with disk storage to hold all input/output messages, a 300 LPM printer and a 600 CPM card reader. Installed at the Memphis site are Honeywell Model No. RCP 701 Terminal/Peripheral systems with specifications identical to those installed at the remote activities.

The four models of Level 66 will allow the Navy to configure the central site installation for the current workload and performance requirements. The initial installation will be configured using Model 66/20 processors. By the time CMI is fully expanded, it is anticipated that the central site will have to be upgraded to a Model 66/60 two-processor system. Detailed equipment lists for the central and remote sites are provided in Table 4-1 and Figures 4-1 and 4-2.

The CMI system was acquired through competitive procurement processes at an estimated cost of $150,000 to the Navy. After 18 months of effort which included the development of technical specifications and workload descriptions, request, receipt, and evaluation of vendor proposals, live test demonstrations by all responding vendors, four vendors submitted the best and final offers. Of the various plans offered by these vendors, the plan which offered the lowest overall systems life cost was selected.

The Navy's CMI computer procurement was a first in many ways. The most significant aspect of this procurement is the 95 percent performance level requirement to be guaranteed by Honeywell for the duration of the systems life.

During the solicitation process, responding vendors were required to convert a significant portion of the CMI data base and application programs to their systems and to demonstrate that the proposed system was capable of processing the projected CMI workloads. Because of the unfeasibility of requiring vendors to install for live test demonstration the large number of terminals that would be required in real time, vendors were instructed to demonstrate only four "live" terminals. The remainder of the workload was also processed during the demonstration but with the vendor being responsible for submitting the workload as if it had come from live terminals. Simulation techniques used included line connection, queue manipulation, and other operating system overheads. As part of the acceptance testing and at any other time during the six year systems life, vendors agreed to rerun the live test demonstrations with all live terminals. In the event the required processing time or required response times were not obtained from the rerun of a live test demonstration, the contractor would provide, at no additional cost to the Government whatever hardware and/or software as required to meet the processing criteria.

Terms and conditions obtained are consistently better than those offered in the GSA contract, e.g., lease discounts range up to 35 percent depending on the type of equipment and time of installation. Purchase option credits range from 45 to 85 percent. Special purchase (quantity) discounts total over 1.5 million dollars. Volume maintenance discounts are offered up to a 40 percent level. All extra use charges were deleted from the contract. Because of these and similar benefits obtainable from competitive procurement, every consideration should be given in future ADPE procurements to going "the long and often discouraging way". Sole-source, negotiated procurement seldom produces similar, if any, discounts, terms, and conditions.

4.3 Current CMI Language

On the Sigma 9, eleven interrelated applicational programs shall be discussed. Their description as well as their timing gives the best concept of the characteristics of the total CMI language package, as well as their operational routines on the Sigma 9. The current

Navy CMI systems programming staff has made significant improvements for efficiencies in the MSU developed programs. Led by Randy Woolley and Carl Weaver, the file handling, cluster interactions, and a new site line concentrator have been effected. The operative CMI programs shall be considered.

1. A-Reg. This program is used to register students for course(s) that are included in the students' curriculum. Students will initially be registered into a course from the Administrative Terminals. The average onboard load divided by the course length in weeks will determine how many students will be registered into the course per week. Since CMI is an individualized self-paced instructional system, there is a steady flow of students through the system. Thus, the weekly input is spread evenly throughout the week. A 1.5 week course with an average onboard of 555 students will receive an average of 74 students per day.

$$555/1.5 = 370$$

$$370/5 = 74$$

2. B-ASSIGN. This program converts symbolic course items into actual course items that are thereby assigned to specific places within the course file. ASSIGN jobs normally are treated as batch jobs that can be loaded at the central site and be processed during slack periods with up to 0.5 hour turn around time. Each week of instructional material requires approximately 150 course file records which require 40 hand-scribed input cards each. Based upon development of the current courses, 1/4 of the original input has to be modified before the course is ready for production usage. Therefore,

7500 cards are required per week of instruction.

$$150 \times 40 \times 1.25 = 7500$$

To achieve the projected course implementation schedule, it is necessary to process 4.333 weeks of instructional materials per month:

$$7500 \times 4.333 = 32500 \text{ cards}$$

$$32500 \div 11 \text{ courses} \div 20.75 = 143 \text{ cards}$$

3. C-MOD. This program builds and maintains the course master file. The MOD Program is processed in the same manner as the ASSIGN Program. The output from the ASSIGN Program is thoroughly and exhaustively edited before being placed into the course master file. This requires many passes through the course file to adequately check the branching techniques.

4. D-EVAL. Evaluate is the student control program. It provides four major functions: entry of students into courses, student progress control, inquiry into student status, and course time keeping.

The "enter" function requires one input record for each student starting the course; therefore it will equal the daily input from the registration process. The "enter" function produces the student's initial learning guide and starts time-keeping functions for the student.

The student's progress through the course is determined by his "responses" to assignments. The number of student responses per day is determined by the course material. Current courses require from 3 to 12 responses per day. The expected overall average is 6 student responses per day. These responses are coded on an answer sheet and read into a scanning device which transmits it to the central computer for processing. An error message or acknowledgment of a properly submitted sheet is returned to the classroom cluster.

Inputs from the inquiry function were not included in the normal workload description but were accounted for by the peak workload description.

The course timekeeping function requires 3 cards per day for each course.

The number of interactions required to process 4755 students in 11 courses is:

4755 students x 6 responses	=	28530
117 students entered		117
Start/Lunch/Stop clocks for the courses		33
		28680 interactions

Past experience has shown that an average of 14 course records must be accessed per response to satisfy the chained branching techniques now being used.

The length of the student's new learning guide will depend upon the course material and the student's progress within the course. Although the lengths of learning guides may vary, the expected average is 20 lines. Learning guide length determines the printing device -- either the cluster printer or the administrative terminal. Under this concept multiple lesson study guides are routed to the administrative terminal, while short one-lesson guides are returned to the classroom cluster. The initial learning guides are always long and are consequently requested from and printed on the administrative terminal.

5. E-DEBUG. The instructors use this program to debug their course file. It prints every item referenced by the "Parent" item.

Therefore, it probes every possible chained path that can be taken as the result of a response to the item. The program input volume is determined as follows:

For 143 inputs to the ASGN-MOD process

114 Adds ÷ 4 cards per add	29
29 Changes ÷ 2 cards per change	15
	44 items

44 items x 2 paths per item = 88 input cards

Run as required as a debugging program for Programs MOD and ASSIGN.

6. F-SYST MAST. The system master update requires approximately 2 input cards per course and is run as required from the central site.

7. G-HIST UPDATE. The student's responses along with information about each module completed are kept in a response file. At the end of the training day, the response file is sorted and merged into a response history file. The history file will contain the student's responses as long as he is active in the course. This job will normally be initiated at the central site.

Response File:

6 responses + 3 module records = 9 records per student each day

History file:

9 records x student onboard load x course length in days

8. H-MATRIX. This program gives a student status report and is run as required for students in the system as requested from the Administrative Terminal.

9. I-HIST PRINT. This program gives a formatted print-out of the student's response and module information. It is run for each

student completing the course or as required. It can be also used to provide the information necessary for counseling and disciplinary action.

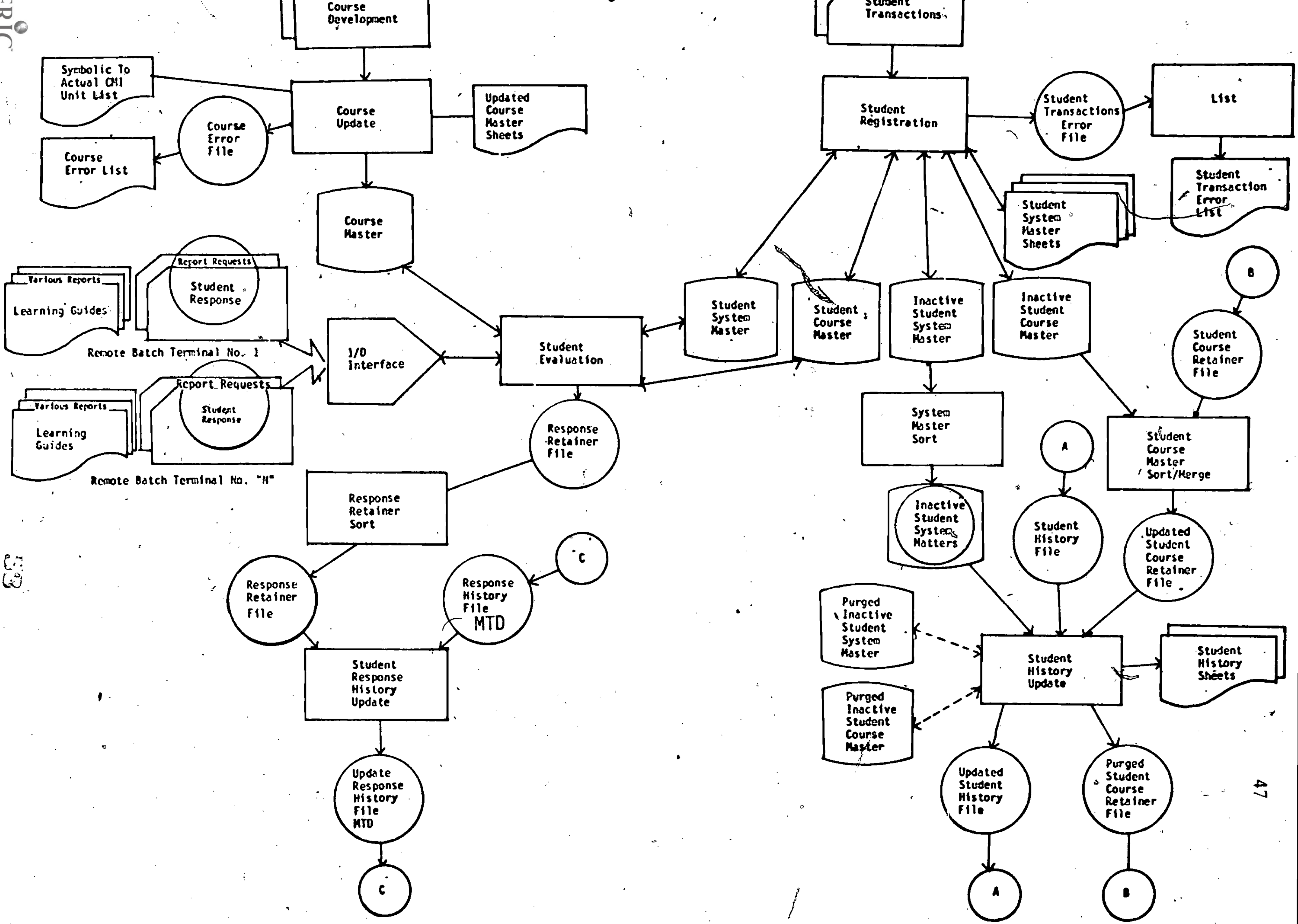
10. J-ROSTER. This program generates rosters. It is run daily for each student enrolled in the system. Runs normally requested from the Administrative Terminals outside of prime training hours.

11. K-PREDICT. This is a monthly regression analysis run against data collected about the students who have completed each course. It is used to predict module learning time and sets the pacing in the course.

CMI Language System

As currently operated, the 11 CMI programs can be considered as being quasi-independent applicational programs. From a systems point of view, they are integrated in terms of work flow. This work flow as originally conceptualized is presented in Figure 4.3. (Note that positive modifications have been incorporated in the interim.) Starting in the upper left hand corner, one can observe that the course development and update process takes place. The course Update Program edits all Course Development inputs, maintains the Course Master File, and causes Course Master Sheets, Course Error Lists, and Symbolic-to-Actual Unit Lists to be printed. Second, the learning guides and student responses interface with the student element ultimately feeding into the student evaluation component, that is, the student evaluation component integrates the course development and course master file with the learning guides and the student responses. The Student Evaluation Program is the main program in the CMI system.

CMI SYSTEMS CHART
Figure 4-3



It evaluates student responses, captures student response data, and causes learning guides, errors in student inputs, and special reports to be printed. Several student evaluation routines have been developed which allow students to respond to multiple-choice tests, true/false or yes/no questions, completion questions, and mathematical questions which require numerical inputs. These, in turn, lead to an ultimate response history which characterizes the student flow. The Response History File contains the following information on each student, by course, by CMI unit: the day he responded to a given CMI unit, the order in which he responded, the amount of credit possible, the amount of credit received, the student's estimate of the instructional and testing time required for each CMI unit, and the entire response made by the student. The information in the Updated Response History is used to generate various reports and provides the data necessary for empirical course development and revision.

In the upper right hand corner there are various activities dealing with the student registration process. The complexity of this is directly proportional to the number of students in the system. The Student Registration Program edits the Student Transactions and causes a list of the errors to be printed. Student System Master Sheets are also generated by the program and are used for various administrative purposes. This program maintains the various student files in the CMI system. Finally, this leads to a student history which merges his response history with his actual requirements in order to track him through the program. The Student History File contains biographical data and summary data which includes elapsed training time, beginning scores, ending scores, points possible, and points received. As you will find in subsequent sections, this system will be re-designed and updated in terms of the new Navy CMI system although these eleven essential functions still are retained.

Language Characteristics

A second way to understand the current Navy CMI language is to code up CMI materials. This coding analysis is offered not as a definitive description (current modifications will likely make even these descriptions obsolete within the very near future) but rather to give some concept of how the coding operation is organized within the system. A clear understanding of how the coding operation is organized within the system illustrates its role and gives a clear understanding of why the coding operation is a cumbersome and high manpower demanding activity. It should be noted that many of the present requirements could be done away with via the use of pre-compilers, that is, a program which compiles natural language input into the appropriate CMI coding formats or via the use of on-line entering and editing (this will be available on the Honeywell system). The concept of on-line entering and editing has become a major feature of the new system.

Formats For Coding Course Material

Three record types are used to code information into the CMI system. They are designated as Descriptor, Statement, and Response Records. Information being coded may require one or more of the record types. The coder identifies the information which he is coding by assigning it a six-character code which will be used to access the information in the system. All of the information which is identified by the same six-character code constitutes a CMI "unit" of information.

The Descriptor Record (there must be one) describes what type of CMI unit is being coded. If the unit requires a student response, the type of evaluation to be conducted is specified as well as the action to be taken as a result of the evaluation (branch schemes). The CMI units which may be accessed are also coded in the Descriptor Record. The following paragraphs indicate the types of information to be coded in the various card columns.

Columns 1 - 3 are used to code a three-character course code. For example, the AMFU(A) course has been designated as course 001, and all CMI units which are prepared for this course will be so designated.

Columns 4 - 9 are used to identify each CMI unit of information. The coders work with symbolic numbers which are coded as one alphabetic character in column 4 and five numerical characters in columns 5 - 9. When units are assembled in the course, they are assigned a subsequent number referred to as the "actual" item number. The first four characters of the "actual" item number identify the track on which the unit is located, and the last two characters identify the position of the unit on a track.

Column 10 contains a code which indicates which type of record is being coded. Descriptor Records are assigned a code of "1".

Columns 11 - 12 are used to identify the type of CMI unit being coded. The first digit indicates the evaluation type, and the second digit identifies the branch scheme to be used.

Columns 13 - 15 are used to place the CMI unit in an instructional segment (benchmark). The benchmark locator allows the CMI system to summarize student data when an instructional phase (benchmark) has been completed. A CMI unit which is located in a particular benchmark cannot reference or be referenced by units which are located in another benchmark. General comments which are presented frequently throughout the course may be referenced from more than one benchmark if they do not carry a specific benchmark locator.

Columns 16 - 20 are used with CMI units which expect a response from the student. Each of the unanticipated branch codes is turned on with a "1" and off with a "0". When a student receives a score of 0 percent which means that the student's response to test items did not result in partial or whole credits being given, the unanticipated branch codes are used. The unanticipated branch codes are directly correlated with the Branch Unit numbers. If the unanticipated branch codes are executed and are coded 01010000, then the information under the unit numbers in the second and fourth positions of the Branch Unit numbers field would be accessed.

Columns 24 - 29 are used when the instructional strategy calls for an evaluation of overall test results in terms of percent correct, and subsequent branching is dependent on the score made. The three percent scores allow as many as four different prescriptions to be made. If 63-75-90 are loaded, the four paths available are below 63 percent, 63-74 percent, 75-89 percent, and 90-100 percent. Of course, different percents may be loaded, and these will depend on the instructional strategy.

Columns 30 - 77 are used to code CMI unit numbers which may be referenced.

Columns 78 - 80 are used to indicate what action is to be taken regarding the record. Additions to a course file are denoted by a "1" coded in card column 78, and columns 79 and 80 are left blank. Changes or corrections to the existing course file are accomplished by the use of codes "2" (insertion), "3" (replacement), and "4" (deletion) in column 78. These actions must be used in conjunction with line numbers which are obtained from a document called the Master Course Listing.

Multiple Descriptor Records may be used for expanded code requirements.

Since the CMI system is designed to accept short answer, numeric, and multiple-choice test responses, the Response Record may be used to accommodate any of these. It can also be used with a variety of evaluation and branch schemes. Several Response Records may be used with specific CMI units to code correct answers, alternative correct answers, and anticipated wrong answers, alternative correct answers, and anticipated wrong answers. Provisions are also made for unanticipated answers (see columns 16 - 23 under Descriptor Record). The following paragraphs indicate the types of information to be coded in the various card columns.

Columns 1 - 3 are used to code a three-character course code.

Columns 4 - 9 identify the CMI unit with which the Response Record is associated.

Column 10 identifies the type of record. Response Records are designated by the number "3".

Columns 11 - 12 indicate the sequence in which the Response Records should be used when evaluating student responses.

Columns 13 - 14 are used only when the student is expected to give a numeric response, and the instructional strategy calls for a tolerance factor to be used in evaluating the student response. For example, if the student were expected to respond with a numerical value to one or a series of problems in electronics and the instructional strategy called for a tolerance factor of ±5 percent, then 05 would be coded in columns 13 and 14.

Columns 15 - 17 are used to assign a weight to the Response Record. The weight is the credit which a student will receive if he receives full credit. If there is only one Response Record coded and the student misses some of the test items, a percent is calculated and multiplied times the weight assigned to the response. In other words, the student may receive partial credit.

If several Response Records are coded, the system will compare the student's response or responses with each of the Response Records (sequentially as indicated by the sequence number in columns 11 - 12) and use the Record which gives the greatest credit. Of course, as soon as a comparison results in 100 percent match, the system uses the particular Response Record.

Columns 18 - 25 are used to reference other CMI units of information whose numbers are coded in the Branch unit field of the Descriptor Record. The use of anticipated Branch codes depends on the type of unit with which the Response Record is associated.

Columns 26 - 27 contain the number of characters which are expected in the student response.

Columns 28 - 77 are used to code the characters against which the student response will be evaluated. The number of characters which can be evaluated under one CMI unit is fifty at the present time.

Columns 78 - 80 are used to indicate what action is to be taken regarding the Response Record and are the same as described under Descriptor Record.

4.4 New CMI Language Functions

The new CMI language is a conversion of the current one and an extension into real time editing and interactive functions. The primary emphasis is on editing and authoring. Extended CMI function like simulation shall be developed by Navy personnel.

The interactive language shall be file compatible with the CMI language and shall implement the editing, authoring, and training simulation requirements. The language complexity shall be minimized so that instructional programmers can learn and perform efficiently.

Text Editing. The on-line text editor shall support data files, FORTRAN, assembler, and COBOL languages. The text editor will have the following abilities:

1. To select an existing file or build a new file.
2. To merge two files or any portion of these files into one.
3. To edit each record within the file randomly and allow for record change.
4. To change a record or records including deletion and/or insertion of a string.
5. To shift a string within a record or records in any direction.
6. To resequence a file being edited and change the sequence number and move a specific record.
7. To update multiple records with an instruction type.
8. To save an edited file by name.

9. To maintain file sequence numbers in such a way that they are transparent when the file is not in edit mode.

10. To copy the file creating an exact duplicate under an alias.

11. To furnish accounting data on file (date or last update, record size, file length, sequence format, etc.)

12. To direct output to another designated terminal.

13. To delete or insert a record.

14. To delete the file.

15. To search records containing a specific string.

16. To display any record or records.

The commitment for interactive problem solving and simulation shall focus on CRT display requirements and formal modeling.

Conclusions

1. The current CMI hardware configuration plus language represents a minimal cost effective training solution because of the 80 to 1 student/terminal ratio, the 30 second or less response time, and a basic minimal set of essential CMI functions yields full achievement of training goals.

2. The new Navy computer represents a cost effective procurement in that a 1.5 million dollar savings plus guaranteed reliability was gained while modular expansion was insured.

3. The guarantees on the reliability and capacity of the new CMI computer are of the highest performance value in that Honeywell is required to insure 95 percent performance and guarantee equipment support if the benchmark standards are not maintained. These are supported by fiscal penalty clauses.

4. The new CMI language shall include the features of editing, authoring, and interactive training which represents a significant increase in complexity and sophistication.

CHAPTER 5. Instructor Functions in Navy CMI

With so much of the interest in CMI focused on monitoring and testing, it is easy to overlook the less salient, but very substantial contribution by the learning center supervisor. The fact that learning center supervisors (LCS) do not present instructional material in the traditional sense should not be taken to mean that their input to the system is inconsequential with respect to learning outcomes. By employing the computer to perform a variety of major instructional tasks (e.g., presentation of assignments, assignment of remediation, evaluation of performance), the LCS, unlike his counterpart in a traditional setting, can devote a substantial portion of his time to tutoring and counseling students on an individualized basis. Students appear highly receptive to this type of support, as evidenced by their tendency, in a recent Navy CMI course evaluation, to give more positive ratings to the LCS than they gave to either the course or the course materials (Thurmond & Hansen, 1975). Moreover, these ratings were found to be appreciably higher than those received by college professors, evaluated by their students in conventional learning environments (Freijo & Jaeger, 1974).

The specific responsibilities of the LCS, although extremely numerous and diverse, has been summarized in terms of six individual categories: administrative, managerial, supervisory, evaluation, diagnostic, and counseling. Administrative duties encompass orienting new students to the instructional system, checking daily printouts from the computer to monitor progress and assign remediation, and notifying the Wing Supervisor when students have successfully completed all course requirements. The managerial and supervisory functions generally consist of helping students to adopt suitable pacing schedules and to make proper use of media for training purposes. In assuming the role of an evaluator, the LCS conducts informal assessments of student performances through oral questioning, observing their work, and daily referencing of the computer printout. With respect to the diagnostic functions, the LCS is expected to carefully evaluate the materials and methods recommended for remedial usage, and select those that appear most appropriate for his students. The final category, counseling, involves the very important responsibility of meeting regularly with students on an individualized basis in order to identify and discuss areas of conflict, to help further their interest and motivation in the course, and to assist them in selecting an academic program that is most likely to accommodate their career goals and learning capabilities.

In light of the above, it seems justified to assume that the effectiveness of CMI systems will depend to a large extent upon the quality (i.e., training and experience, attitudes, and overall instructional abilities) of its LCS. A systematic analysis of LCS characteristics, therefore, must be considered an essential component of any serious attempt to describe or evaluate CMI.

Purpose of the Study and Data Collection Procedures

In accordance with the rationale stated above, a primary objective of the present study was to gain insight into the personal characteristics (i.e., training, attitudes toward CMI, etc.) of LCS's currently employed in the CMI technical training system at NAS Memphis. The basic methodology involved administering a paper and pencil questionnaire to a sample of 123 LCS's who presently hold positions in the NAS Memphis CMI training system. To help insure the validity of results, precaution was taken to preserve the anonymity of the respondents. Specifically, once the questionnaires were administered, the respondents were allowed to complete them independently, without intrusion by their superiors or by any individuals connected with the present study. Each respondent was given a phone number and the name of an individual who could be contacted if questions arose while completing the questionnaire. Most importantly, preliminary instructions indicated that names should not be written on the questionnaire form since there would be no interest in determining the identities of individuals.

The finalized version of the questionnaire contained 31 items, grouped according to three separate categories: (a) a demographic section, consisting of five items, used to collect background information (age, military, and CMI experience, etc.) pertaining to the sample being described; (b) an "attitudinal" section consisting of 15 statements describing various applications and objectives of CMI (the LCS reacted to the statements by selecting multiple-choice alternatives or, in many instances, by indicating levels of agreement or disagreement on a five-point Likert-type scale); and (c) a supplementary attitudinal section containing 11 statements about CMI with the requirement that responses be open-ended. The questionnaire may be viewed in its entirety in Appendix B.

Results

For purposes of clarity and convenience, the findings relating to each of the three sub-scales comprising the questionnaire will be treated separately.

Demographic Data

The first five items on the questionnaire were used to collect basic background information relating to the respondents. In Table 5-1, the findings show the percentage of supervisors who fall into specific categories associated with age, years in the military, military status, years experience with CMI, and educational background. Since these results are mostly self-explanatory, the description to follow will be fairly brief in nature.

The total sample was fairly homogeneous with respect to background characteristics, with age, perhaps, being the only exception. A profile of a "typical" or "representative" respondent would suggest that he would be between 21 and 40 years of age, enlisted in rank, fairly experienced in military service but inexperienced in working with computers, and educated through or a few years past the high school level.

Attitudinal Data

A total of 15 items comprised this portion of the survey. In summarizing results pertaining to items for which the selection of more than one response was permissible, frequencies rather than percentages will be reported.

TABLE 5-1

SUMMARY OF DEMOGRAPHIC DATA*

1. Age

1.6% : Less than 21 years
22.8% : 21-25
24.4% : 26-30
20.3% : 31-35 years
23.6% : 36-40
7.3% : over 40

2. Years in Military

1.6% : Less than 2 years
19.5% : 2-5
22.8% : 6-10 years
56.1% : over 10

3. Military Status

95.1% : Enlisted
4.9% : Civil Service

4. Experience with Computers

51.2% : Less than 1 year
39.8% : 1-3
6.5% : 4-6
2.4% : 7-9

5. Educational Status

1.6% : did not finish high school
56.1% : high school diploma
36.6% : some college experience
4.9% : college diploma
.8% : advanced degree

* the data are expressed in terms of percentages of those falling into specific descriptive categories

The extent of computer usage in military training. (Item #1, 2, 3, 9). Four of the items were used to survey opinions concerning the extent to which computers are, and should be, employed for military training. The complete items statements and their corresponding alternatives can be seen in the appendix. The vast majority of responses were distributed fairly evenly across the four less extreme categories, with the greatest number (25.2 percent) reflecting the view that CMI presently accounts for 11 - 20 percent of military training.

More revealing, perhaps, from the standpoint ascertaining attitudes toward CMI, were the responses to Item #2, indicating the extent to which LCS's believed that computers should be employed. Approximately 37 percent of the respondents expressed the opinion that computers should be used much more (24 percent) or slightly more (13 percent) than is presently the case; only 19 percent thought that the amount of computer usage should be reduced. The supervisors were generally in agreement in reacting to Item #3, with almost 85 percent indicating that the extent of computer usage will probably increase in the future. However, the question of whether the increased use of computers will further productivity in training produced little uniformity of response: almost 40 percent of the sample believed that this would be the case, 18 percent were undecided, and 42 percent disagreed with this notion.

The overall impression one obtains from the above data is that the typical learning supervisor is more likely to support than disagree with the notion that the amount of computer usage should be extended beyond its present usage. There is considerable disagreement among learning supervisors on the question of whether computer usage is likely to increase productivity in training, however. About half feel that it will and about half feel that it will not.

Effectiveness of CMI relative to other systems (Items #4, 6). The responses by learning supervisors to Items 4 and 6 indicate an extremely positive attitude toward CMI relative to alternative training strategies. Specifically, 61 percent of the sample agreed or strongly agreed with a statement (Item #4) to the effect that the feasibility and usefulness of CMI are obvious and no longer in question. It is also encouraging to note that when the supervisors were asked to select the most desirable instructional mode for military training, CMI emerged as the most popular choice (44.7 percent), followed by conventional instruction (34 percent), tutorial CAI (9 percent), and programmed manuals (5 percent).

Problems associated with CMI systems (Item #5). The supervisors were asked in Item #5 to identify what they perceived to be the two most significant problems relating to the present use of computer technology in military training. Out of the 123 supervisors tested, 55 identified "instructor attitudes" and 54 identified "cost" as the most important barriers to the successful implementation of CMI programs. The fact that instructor attitudes was the most frequent choice is surprising in light of the favorable views expressed toward CMI in response to other items (see Items #4 and #6, above). It may be that supervisors interpret the problem as one involving poor attitudes by their colleagues, even though they, themselves, may react positively toward CMI. Other problems relating to CMI were identified as student attitudes (f = 47), insufficient hardware technology (f = 37), and poor organizational climate (f = 22).

Advantages of CMI (Item #12). The three major advantages of CMI were perceived by the LCS's to be (1) savings in instructional time (f = 82) (2) flexibility in handling varying training loads (f = 56) and (3) adaptability to individual differences (f = 46). Other reasonably popular selections were that CMI: offers greater uniformity in the quality of training (f = 39); provides greater assurance that instructional objectives will be met (f = 29); and saves money (f = 26).

Characteristics of students (Items #7, 10, 13, 14). In responding to Item #7, most learning supervisors (77 percent) expressed the belief that CMI is more likely to benefit students who are average (22 percent) or above average (49 percent) in learning ability. Only a small proportion (14.6 percent) selected the below average student as the one most likely to derive benefits from computer-based instruction. The learning supervisors, as a whole, also seemed to regard CMI as more advantageous for enlisted men at the entry level (f = 68) or beyond it (f = 53) than for cadets (f = 23), officer candidates (f = 26), or officers at basic or advanced levels of training (f = 37).

The role of the learning supervisor in CMI (Items #8, 11, 15). The findings to be discussed in this section relate to the supervisors' attitudes regarding (a) their own influences in computer-based instruction (b) the nature of their responsibilities and (c) the training requirements of their profession. With respect to the first of these topics (Item #8) the majority of respondents appeared to feel that their influence on students and learning outcomes is not as great as that of conventional classroom teachers: 31 percent defined their roles as "considerably less influential"; 32.5 percent defined it as "slightly less influential"; and 19.5 percent viewed it as comparable in influence to conventional instruction.

Even though the learning supervisor may assume a less central position in the classroom relative to his counterpart in the traditional setting, his instructional responsibilities, nevertheless, are numerous and diverse. Item #15 on the questionnaire listed some of the more important of these responsibilities and asked the supervisors to select the one which, in their opinion, generally required the most time and effort. The results indicated that the greatest number of supervisors identified "answering questions from students" (39 percent) as their most time-consuming activity, with relatively fewer selecting (in descending order) counseling students (21 percent) basic administrative duties (19 percent), providing remedial assistance (12 percent), and disciplining students (about 3 percent).

Finally, there appeared to be little agreement among the respondents as to the best procedures (training requirements) for selecting learning supervisors for assignment (Item #15). Many thought that personality and attitude test scores comprise extremely useful criteria ($\underline{f}$ = 41), but almost an equal number ($\underline{f}$ = 37) indicated that supervisors should be selected for assignment simply because they volunteer. Less support was voiced for selection criteria based on MOS or skill identities ($\underline{f}$ = 27), prior teaching experience ($\underline{f}$ = 24), availability of candidates ($\underline{f}$ = 11), or prior knowledge of computers ($\underline{f}$ = 8).

Summary. In general, the attitudinal data suggest that most of the learning supervisors tested react favorably to computer-based instruction, viewing it as preferable to conventional instruction and believing that its usage should (and will) be extended in the future. The consensus of opinion appears to be that CMI is most applicable (beneficial for) to enlisted personnel, but is unlikely, by itself, to comprise a cause for increased enlistments by eligible candidates. The major advantage of CMI was identified as savings in instructional time, whereas the major disadvantages were viewed as instructor attitudes and cost. The supervisors, for the most part, view their role as less influential than that of the conventional instructor and feel that it primarily involves, in terms of time and effort, answering questions from students, counseling, and basic administrative duties. Selecting individuals for assignment as supervisors should be based, according to most respondents, on personality and attitude test scores and according to whether or not the candidate volunteers.

Supplementary Attitudinal Data (Open-ended Responses)

The open-ended section of the questionnaire encompassed eleven questions, all requiring responses that could generally be phrased using one or two key words or, at most, a brief sentence. These responses were evaluated by two independent judges and grouped separately for each question according to similarities in content (or point of view). From these groupings, the percentages of LCS's expressing specific views could be determined. In the interests of brevity, and recognizing that there was a fair amount of overlap in what was measured in the two attitudinal sections of the questionnaire, the present summarization of results will be mostly restricted to a reporting of the actual numerical data with little attempt at interpretation or verbal description:

<u>Question #1</u>: How important is the role of the learning supervisor? General reaction was that supervisors' role is important:

Responses:

Very Unimportant	13.0%
Unimportant	3.3%
Neutral	6.5%
Important	2.4%
Very Important*	47.2%

*Percentages may not add up to 100 percent due to the fact that some respondents left items blank.

<u>Question #2</u>: How helpful was on-the-job training in preparing you for CMI? Opinions were divided, but more respondents seemed to feel that on-the-job training was helpful rather than not helpful in preparing for CMI:

Responses:

Not helpful	20.4%
No opinion	15.4%
Helpful	34.2%

<u>Question #3</u>: How useful was Instructor Training School in preparing you for CMI functions in the areas of instructional techniques, materials, testing, and ISD?

Most respondents regarded Instructor Training School as not particularly helpful in the above areas. The data shown below relate specifically to the area of instructional techniques, but are generally representative of the results obtained for the three remaining areas -- materials, testing, and ISD:

Responses:

Not helpful	35.0%
No opinion	9.8%
Helpful	10.6%

Question #4: What proportion of students seem unconcerned with trying to succeed?

The general reaction was that less than 20 percent of the students did not try to succeed:

Responses:

Less than 20%	48%
Between 20% and 50%	9%
More than half	3.2%

Question #5: What techniques do you use to motivate students?

The most popular responses were:

1. Counseling (f = 41)
2. Threats or fear (f = 15)
3. Appeals to self-pride (f = 7)

Question #6: Overall, how successful has CMI implementation been in your training program?

The general reaction was that implementation has been reasonably successful:

Responses:

Unsuccessful	11.4%

No opinion 23.6%

Successful 32.5%

Question #7: Has the CMI system increased the productivity of the training program?

Most of the learning supervisors felt that productivity had been increased:

Responses:

No 9.8%

Sometimes 16.3%

Yes 47.2%

Question #8: How successful is CMI in achieving instructional objectives?

Most responses suggested that the success of CMI in achieving instructional objectives ranged from "fair" to "good":

Responses:

Poor 12.0%

Fair 25.0%

Good 30.1%

Question #9: What are the most successful features of CMI?

The most frequent reactions defined the most successful features as:

(1) time savings (f = 27)

(2) self pacing (f = 23)

(3) reduction in paper work (f = 10)

Question #10: What are the least successful features of CMI?

The most frequent responses were:

(1) united student/instructor relationship (f = 21)

(2) unavailability of computer (f = 14)

(3) low retention of material (f = 13)

Question #11 : Additional comments?

Among the more popular responses were that there is some need for:

(1) more on-the-job training (f = 16)

(2) an alternative system to CMI (f = 9)

(3) ways to increase student motivation (f = 9)

Between Groups Comparisons

Additional analyses of the questionnaire data were performed to test the hypothesis that LCS's might react differently toward CMI as a function of (1) the particular school to which they were assigned (BE/E; AFUN; ADJ) and/or (2) their chronological age (less than 25 years; 25-35 years; over 35 years). The data were analyzed for each item separately via a simple one-way analysis of variance.

The findings (the outcomes of 38 analyses) offer little support for the above hypothesis. Comparisons between the three schools yielded significant differences ($p < .01$) in responses for only three of the 19 items. The direction of the data suggested that LCS's representing the BE/E school were more likely than their counterparts to feel that the implementation and usage of CMI should be extended (Pt. II: Items # 2, 4); and that CMI has been successful in achieving instructional objectives in their training system (Pt. III: Item # 8). This is understandable in that BE/E has had the longest experience with the current version of CMI. The reader should be warned, however, that these results must be viewed with caution since they were not corroborated by outcomes for similar items and because the very large number of independent analyses conducted prevented the control of the familywise risk of a Type I error. As far as comparisons between age groups were concerned, the findings were even less conclusive: no significant differences were obtained in any of the analyses. On the basis of these results, it seems reasonable to conclude that neither type of school nor chronological age were significant determinants of how LCS personnel tended to react toward their profession and toward CMI in general.

Conclusions

1. The learning center supervisors have a high positive orientation towards CMI and have clearly committed themselves to its professionally demanding role.

2. Students rate the learning center supervisors and CMI in highly positive terms; in fact, these ratings are more positive than commonly found in collegiate atmospheres.

3. The learning center supervisors perceived the benefits of the CMI system in terms of its objectives (e.g., time saving) or their role (tutoring and counseling) rather than in the assumed functions of test scoring or registration.

CHAPTER 6: Instructional Systems Development for Navy CMI

Critical to the implementation of the Navy technical training CMI system is the conversion of existing conventional courses into a computer-based individualized mode. This conversion requires personnel capable of performing the various functions relating to the Instructional Systems Development (ISD) process with the added capability of computer coding and debugging. Similar to the investigation of the Learning Center Supervisors, this chapter focuses on the personnel implementing this course conversion and maintenance process.

The Instructional Systems Development (ISD) personnel phase of the Navy CMI utilized a survey strategy. A questionnaire was developed and administered to a sample of ISD personnel to solicit information relative to the CMI operations at NAS Memphis. The Instructional Systems Development Personnel Questionnaire was developed by the project team and reviewed by training personnel at NATTC for refinements. The questionnaire consisted of 16 items that solicited open-ended responses. The questions focused on areas such as the roles and tasks of ISD personnel, strengths and weaknesses of the developmental procedures used, accomplishments of CMI, and hindrances to CMI.

The questionnaire was distributed to a sample of ISD personnel at NATTC. Thirteen respondents completed the questionnaire and returned it. The responses were synthesized for each question for presentation in this report. The results are presented in summary form in the following paragraphs.

QUESTION 1

How well does the ISD Model serve in the implementation of CMI?

The responses are summarized as follows:

Very well	6	(46.2%)
Moderately well	5	(38.5%)
Not familiar with ISD Model	2	(15.4%)

About 85 percent of the respondents indicated that the ISD Model serves as an adequate guide for implementing CMI. The other respondents were not familiar with the ISD Model. Typical responses were "very effective" and "adequately as a broad guide model."

QUESTION 2

What are the major problems encountered in preparing the curricular materials for CMI?

The responses were grouped and tabulated as follows:

Setting job tasks	5	(38.5%)
Setting terminal objectives	4	(30.8%)
Preparing appropriate materials	3	(23.1%)
Determining content to be covered	2	(15.4%)
Obtaining capable writers	2	(15.4%)
Overcoming resistance to change	1	(7.7%)

(The percentages of responses add to more than 100 because some respondents identified more than one problem.)

The principal problems encountered in preparing CMI curricular materials relate to providing task analyses of job performance and establishing terminal objectives for courses. Less frequently mentioned problems concern preparing appropriate materials, determining the content for materials, and competency of writers. Examples of comments are: "proper job tasks," "determining terminal objectives," "determining what material is required to attain objectives," and "trying to determine what is to be covered."

QUESTION 3

What aspects of the curriculum are adapted to CMI more easily?

The compilation of 19 responses to the question were summarized as follows:

Knowledge	7 (53.8%)
Theory	5 (38.5%)
Classroom instruction	3 (23.1%)
Testing	3 (23.1%)
All written materials	1 (7.7%)

Knowledge and theory are clearly the areas of learning that are seen as most amenable to CMI. Classroom instruction, a more general area, and testing are also seen as appropriate for CMI. Typical responses are: "knowledge behavior," "knowledge and theory instructional areas," "classroom theory type lessons," "classroom situations," and "evaluation."

QUESTION 4

What are the most difficult tasks in implementing a CMI system?

The results of the tabulation of responses to this question were as follows:

Teaching manipulative skills	5 (38.5%)
Overcoming resistance of staff	3 (23.1%)
Teaching on-the-job skills	2 (15.4%)

Achieving uniform quality of materials	2 (15.4%)
Training instructional personnel	2 (15.4%)
Procuring facilities, hardware, and materials	2 (15.4%)
Complying to administrative requirements	1 (7.7%)

The respondents perceived that the greatest difficulty was encountered in teaching certain skills: manipulative and on-the-job. A relatively small percentage of the respondents also mentioned difficulty in achieving uniform quality of materials, acquiring resources, and training instructional personnel for CMI operations. Illustrative comments are as follows: "teaching manipulative skills," "overcoming resistance to CMI by conventional instructors and managers," "job skills," "training the required personnel," and "creating programmed instruction to a uniform standard."

QUESTION 5

How could the implementation of a CMI system be improved?

The comments of the respondents are summarized as follows:

More cooperative efforts among personnel at various levels	5 (38.5%)
Provide specialized implementation personnel	3 (21.1%)
More training of involved personnel	2 (15.4%)
More assets	1 (7.7%)
Create setting for tryouts	1 (7.7%)
No comment	2 (15.4%)

The three most frequently mentioned ways of improving CMI implementation involve personnel. Most frequently cited was the need for more cooperative efforts among the personnel involved. Provision of specialized implementation personnel was mentioned by about one-fourth of the respondents. Examples of the comments were "getting all concerned to work together," "by coordination and understanding of the system by all parties concerned," "have a cadre of skilled people do the whole job or closely supervise it," and "more training of school administrators and personnel tasked with implementation."

QUESTION 6

How does CMI improve the quality of instruction?

The tabulation of responses produced the following results:

Standardization of course content	8 (61.5%)
Individualization, self-pacing	4 (30.8%)
Efficiency of time and effort	3 (23.1%)
Unbiased	1 (7.7%)

The principal improvement in the quality of instruction by using CMI was identified as the uniformity of content that is taught in individual courses. The capability to individualize instruction and the efficient use of time and effort were also mentioned as ways that CMI contributes to instructional improvement. Typical comments by the respondents were "teaches each student the same material," "self-paced and individualized instruction," and "saves time for the student and the instructor."

QUESTION 7

What is your reaction to the procedures utilized in implementing CMI in your training program?

The summarization of the respondents' comments produced the following results:

Positive	10 (76.9%)
Negative	1 (7.7%)
No comment	2 (15.4%)

Three-fourths of the respondents made comments of a general or specific nature that were positive. Only one comment was negative in tone. Some examples of positive comments are "the procedures were well-planned and properly utilized," excellent when trained personnel are used," and "too much emphasis on empirical development and not enough on assessment of feedback."

QUESTION 8

What roles do you fill in developing CMI materials?

The responses to this question revealed the following roles:

Task analysis	3 (23.1%)
Writing materials	3 (23.1%)
Coordinating instructional procedures and software development	2 (15.4%)
Course coding	2 (15.4%)
Implementing ISD	2 (15.4%)
Editing materials	1 (7.7%)
Supervisory programmers	1 (7.7%)
Test development	1 (7.7%)
No comment	1 (7.7%)

The comments of the respondents reflected that a great variety of roles are filled in developing CMI materials. Task analysis and writing course materials were specified by about one-fourth of the respondents. Less frequently mentioned were functions relating to coordination of instructional and software development, course coding, and editing materials.

QUESTION 9

How many man-hours are required on the average for you to prepare one hour of CMI materials?

The answers of the respondents were as follows:

10-12	1 (7.7%)
30	1 (7.7%)
40	1 (7.7%)
70	1 (7.7%)
150	1 (7.7%)
Unknown	4 (30.8%)
No comment	4 (30.8%)

The responses concerning man-hours required for producing CMI materials were highly variable, ranging from 10 - 12 to 150. The responses were exemplified by the following: "40 hours average, depends on the number of objectives for the particular lesson;" "unknown, depends on material being prepared," and "from start to finished product, one would estimate 30 hours."

QUESTION 10

What tasks do you perform in developing CMI materials?

The compilation of responses provided the following results:

Develop or write materials	5 (38.5%)
Analysis	4 (30.8%)
Edit materials	2 (15.4%)
Code materials	2 (15.4%)
Identify and develop tests	2 (15.4%)
Validate materials	2 (15.4%)

Design materials	1 (7.7%)
Review materials	1 (7.7%)
No comment	3 (23.1%)

The tasks that were identified by the respondents were varied in nature. About two-fifths of the respondents indicated that they develop or write instructional materials for CMI while about one-third referred to analysis of the learning tasks to be accomplished. Other tasks included functions such as editing materials, coding materials, test development, and validation.

The responses revealed three primary areas of difficulty in developing CMI materials: developing objectives from task analysis results, utilizing clearly understood language in materials, and assemblying materials and aids needed for the courses. Illustrative comments were "conversion of each task selected for training into an instructional objective," "presenting the material in language easily understood," and "getting all materials together that are to be covered."

QUESTION 11

What are the greatest difficulties encountered in developing CMI materials?

The comments relating to difficulties were summarized as follows:

Converting tasks to clear objectives	4 (30.8%)
Using understandable language in materials	4 (30.8%)
Assemblying materials/aids	4 (30.8%)
Starting development process	1 (7.7%)
Validating materials	1 (7.7%)
Resistance to change	1 (7.7%)
No comment	2 (15.4%)

QUESTION 12

What are your most rewarding activities in developing CMI materials?

The comments of the respondents were tabulated with the following synthesis resulting:

Effective instruction	9 (84.6%)
Developing instructional media and materials	2 (15.4%)
No comment	2 (15.4%)

Most of the respondents suggested that the accomplishment of effective instruction is the most satisfying aspect of developing CMI materials. The materials and media of instruction were the reward for a relatively small proportion of the respondents. Typical comments are "seeing individuals progress," "a good final product," "seeing the materials working in the learning centers," and "development of instructional media."

QUESTION 13

How successful is the CMI system in achieving instructional objectives?

The categorization of responses to the question produced the following results:

Very successful	9 (84.6%)
Moderately successful	2 (15.4%)
No comment	2 (15.4%)

The respondents expressed very favorable views regarding the success of CMI in reaching the instructional objectives that it addresses. Examples of their comments are "highly successful," "very good for basic information," "success is in proportion to criteria of testing," and "very successful in theory-type lessons."

QUESTION 14

What types of resistance to CMI do you encounter in your training program?

The comments of respondents regarding resistance were summarized as follows:

Opposition to change by personnel involved	9 (69.2%)
Opposition to CMI philosophy/ systems approach	4 (30.8%)
Unspecific	2 (15.4%)
No comment	1 (7.7%)

The principal source of resistance to CMI appears to be based on opposition to change from personnel in various roles and at various levels. Some resistance also is derived from opposition to the philosophy of CMI and the systems approach to instruction. Illustrative comments are that "tremendous human inertia," "people's resistance to change from platform situations to CMI," "extreme resistance from some persons involved with part curriculum and lockstep teaching," and "personnel who do not believe in the systems approach."

QUESTION 15

Overall, how much job satisfaction do you find in developing CMI systems?

The responses to this question were classified and tabulated as follows:

Above average	9 (69.2%)
Average	1 (7.7%)
No comment	3 (23.1%)

More than two-thirds of the respondents indicated that they derived above average job satisfaction from their work in developing CMI systems. Typical comments were "personally--a lot," "very satisfied with my role in developing instructional materials," "the most satisfying and challenging endeavor encountered in technical training," "I find it gratifying," and "a sense of accomplishment by producing well-trained Navy men."

QUESTION 16

Additional comments about CMI.

About one-half of the respondents made additional comments concerning CMI. The comments were summarized as follows:

Positive	4 (30.8%)
Need more support	2 (15.4%)
No comment	7 (54.8%)

One-third of the comments made were positive in tone while others related to support for CMI. The comments are exemplified by the following: "It's the going thing," "the greatest aid to mass media since the comic book," "the CMI method of teaching is the method of the future," and "more formal training is needed in CMI concepts and skills for administrators of schools and courses."

CONCLUSIONS

1. CMI is perceived as the best Navy alternative for individualizing the training process; therefore, curriculum specialists like Learning Center Supervisors rate it highly and are committed to its implementation.

2. While there are personnel resistance factors, the majority of the curriculum specialists rate their roles as challenging, within the

ISD mission and professionally rewarding. This highly positive level is rather unusual for computer based systems (see Chapter 8) and reflects the high proportion of uniform personnel supporting the effort.

CHAPTER 7. Cost Benefits to the Navy from the CMI System

Cost benefit analysis has many forms, each of which reflects the types of questions being addressed. For our purposes, this section shall compare conventional instruction (CI) with CMI. It is precisely the outcomes of this comparison that has caused the Navy to move aggressively forward into a CMI operation. To perform this CI-CMI comparison, the projected cost benefits as proposed in the original justification to the CNO shall be considered. In turn, the unfolding cost benefits as reflected by the FY 75 training data coming from NAS Memphis shall yield our current level of cost-benefit aggregation. Finally, the benefits to the operational Navy shall be discussed.

Projected CMI System Cost Benefits.

This section shall define cost elements so that the cost benefits can be derived. Within NATTC Memphis there are three cost elements, exclusive of student salaries, which contribute most heavily to the training cost per student. These elements are instructors, direct support, and indirect support personnel salaries. (Minor cost areas are supplies, travel, etc.) The instructor and direct support costs are those directly identifiable with a given course. Indirect support includes all other NATTU Memphis personnel.

The number of instructors required for a given course is a function of three variables: Instructional hours required at given student/instructor ratio; annual training requirement in number of students: and class convening frequency.

Support requirements are, in the aggregate, a function of the number of students on-board. The planned students on-board to direct support ratio at NATTC Memphis in 1972 was 24.2:1. The planned student input to indirect support ratio at NATTC Memphis in 1972 was 12.43:1.

Courses to be converted to CMI were so chosen because of their impact on the Technical Training Command in terms of resources required. The FY 75 training plan calls for an average student on-board (AOB) load of 20,261 for these courses. This requires 2,691 instructors and 2,467 support personnel at a cost of about $29,043,963 for instructors, and $30,615,181 for support personnel per year. Student salaries are about $121,566,000. This totals to about $181,225,144 per year for student, instructor, and support personnel salaries and benefits. These costs do not reflect local command, facility, travel, CNTECHTRA, and CNET overhead.

The courses put under CMI demonstrated significant course length reductions compared to conventional instruction. (See Chapter 3, a 46.9 percent reduction.) A conservative 20 percent reduction was used for this FY 74 analysis rather than the targetted 30 percent set as an objective. Course length reduction has a direct proportional effect on student average on-board (AOB), which is used to derive instructor and support requirements. Consequently, it becomes apparent that even a very modest course length reduction of 20 percent has an impressive gross cost savings/avoidance potential on the order of several million dollars per year. CMI reductions in instructor requirements for a projected 20 percent-course length reduction are generally on the order of 20 percent. This is due primarily to lower AOB's realized as a direct function of course length reductions and, secondarily, to greater instructional efficiencies.

Curriculum development constraints (personnel, funds, facilities) coupled with hardware acquisition projections dictate an implementation plan spanning a five year period. The projected implementation plan is presented in Table 7-1. Each projected course conversion by fiscal year is listed. (Obvious exceptions have occurred, for example, the ADJ course is now operational although it was not scheduled until FY 77.).

Cost Objectives

CMI has two primary cost objectives in addition to individualized training: course length reduction and an increase in student to instructor ratios. The objectives are both manageable and can be quantified.

Course length reduction provides the most significant gains and is directly measurable. Each course to be implemented was or is presently being taught under conventional instruction. The number of hours required to teach each course is well documented. Under CMI, after a statistically significant number of students have completed the course, an average completion time may be computed. The difference between the time required to complete a given course of instruction under conventional instruction (CI) and the average completion time under CMI is the course length reduction. A conservative course length reduction of 20 percent overall shall be used for analyses, a reduction of 30 percent is the primary objective of CMI.

For each course under consideration the CI student to instructor ratio used for theory/practice instruction is 25:1. This is both the classroom standard or guide and the ratio normally used to determine

Table 7-1

Projected CMI Course Loadings

FY	School	Location	Course Length (# of weeks) est.	Estimated Students under Instruction CI	CMI	TOTAL
				20667	0	20667
74	BE/E	Memphis	5.4	19876	633	20509
74	AFUN	Memphis	0.9	19001	1333	20334
74	SPLICE	San Diego	5.4	18028	2111	20139
75	AV(A)	Memphis	3.0	17650	2413	20063
75	SPLICE	Great Lakes	5.4	16171	2596	19767
76	AV(A)	Memphis	12.8	15439	4182	19621
76	SPLICE	Orlando	18.0	15106	4449	19555
76	SPICE	San Diego	18.0	14016	5306	19322
76	SPLICE	Great Lakes	18.0	12016	6903	18919
76	MM/BT	Great Lakes	9.0	9572	8858	18430
77	AM	Memphis	6.4	8945	9360	18305
77	AE	Memphis	12.0	8332	9851	18183
77	AD	Memphis	5.6	7959	10150	18109
77	HT	San Diego	19.4	7231	10733	17964
77	RM	San Diego	11.2	6244	11522	17766
77	EM	San Diego	9.6	5640	12006	17646
77	OS	Great Lakes	12.0	4973	12539	17512
77	FT	Great Lakes	21.6	4350	13038	17388
78	AFTA	Memphis	20.8	3693	13564	17257
78	AC	Memphis	10.4	3502	13717	17219
78	AO	Memphis	8.8	3215	13946	17161
78	AW	Memphis	9.6	2975	14138	17113
78	IC	San Diego	10.4	2680	14374	17054
78	CS	San Diego	6.4	2409	14590	16999
78	ETSIMP	Great Lakes	17.6	1203	15555	16758
79	CLERICAL	Meridian	6.8	405	16193	16598
79	GM	Great Lakes	9.6	0	16517	16517

BE/E Basic Electronics/Electricity
AFUN Aviation Fundamentals
SPLICE Systems Planned Learning Individualized Core Elements
AV(A) Avionics
MM/BT Mechanical Mate/Boiler Technician
AM Avionics Structural Mechanic
AE Avionics Electrician's Mate
AD Avionics Mechanical Mate
HT Hull Technician
RM Radio Mate
EM Electrician Mate
OS Operation Specialist
FT Fire Controller Technician
AFTA Advanced 1st Term Avionics
AC Air Controller
AO Avionics Ordinance
AW Avionics ASPA
IC Internal Communications Electrician
CS Commissary Specialist
ETSIMP Electronics Technician Simplified
GM Gunnery Mate

instructor billet requirements. Under CMI the objective is to raise this ratio to 30:1. Again, this objective is directly measurable by observing the number of instructors required with CI and CMI.

Cost Elements

Costs are presented below for the estimated eight year life cycle of the system for the accepted alternative:

(1) Continue with Conventional Instruction

(2) CMI with lease-purchase ADPE

To determine the taxpayer cost to train a student there are nine cost elements to be considered. These are presented in Table 7-2.

Comparison of Projected Cost for CMI and CI By the FY 74 Plan

For the purposes of this projected analysis, only the cost savings in instructor and support personnel plus that attributable to avoidance in student salary given the reduced student load were considered. Table 7.3 presents the CMI reduction of instructor and support billets. (It should be noted that after six years the instructor and support reductions stabilize.) As one can see, the total savings for this six year period is $13 million plus and the annual savings range from approximately $1 million through $4.4 million.

In turn, the student billet reduction is indicated by the reduction of the average on-board load, drops from 20,667 to 16,517. This equates to an avoidance of approximately $22 million per year or $148.6 million for the 8-year period from FY 74 through FY 82.

Therefore, in calculating the total costs savings, one can perceive that the cost for computer managed instruction will be $426,603,000

Table 7-2

Cost Elements for CMI and CI

CMI Elements	Common Elements	CI Elements
ADP	Supplies	Instructors
Less Instructors	Travel	Support
Less Support	Plant	
Course Conversion	Indirect overhead	
	CNET/CNTT overhead	

Table 7.3

Projected Cost Savings for Instructors and Support Personnel in CMI

FY	Instructor Billets	Support Billets Mil	Support Billets Civ	Total Billets	Dollar Cost Savings MP, N	Dollar Cost Savings O&MN	Annual $ Savings
75	87	59	8	154	1652	119	1771
76	155	102	13	270	2891	208	3099
77	221	149	21	391	4163	300	4463
78	131	88	11	230	2484	179	2663
79	54	35	5	94	1011	72	1083
80	6	3	1	10	100	7	107
Total	654	436	59	1149	12301	885	$13186

while the cost for conventional instruction is $625,870,000, a difference of $199,267,000. Thus, the initial projected analysis indicates that the CMI alternative provides significant cost savings. It should be recalled that the projected cost savings are figured at the 20 percent level to be conservative, but in fact, the savings are operating at 46.8 percent currently. Turning from these projected cost benefits, the realities of FY 75 yield cost benefit figures of an even more positive character.

Cost Benefits Achieved For FY 75

As presented in the prior section, the cost benefits for the Navy CMI system look most advantageous. As with any system, though, the reality of its beginning implementation determines whether the projected benefits are being realized. This section speaks directly to this reality.

For comparative purposes, the fiscal year 1973, just prior to beginning operational implementation of CMI shall be used. Therefore, the following analysis for FY 73 as opposed to FY 75 is composed within the four CMI objectives.

Reduced Course Time. As presented in Table 7.4, one can see that the number of AOB students has increased, and given our awareness that for each of the courses there has been a significant drop in length (a reduction of 46.8%), this yields a savings in student salaries of $10,106,604 (difference of AOB-2199- x salary of E2 x 45%). This savings of 10.1 million dollars is approximately 48 percent of the total projected life cycle savings. Obviously, this should grow

Table 7.4

Cost Saving for FY73 to FY75

	Conventional Instruction	
Student AOB	1632	2,500*
Course Time	196 hrs.	104.3 hrs.
Course Reduction	-0-	46.8 %
Projected Student Load Factor for CMI	4699	-0-
Amount of Savings in Student Salaries	-0-	10,106,604

*AOB Level Average for Year

considerably as the CMI system moves on into bigger student loads. Not only should bigger student savings be expected (higher load and higher salaries), but this illustrates how CMI responds flexibly and cost effectively to new manpower requirements.

Instructor and Support Personnel. As presented in Table 7.5, the data indicates that there has been a significant drop in instructor personnel (23 percent). Given that these are on the average, E-7 level, this yields a savings of approximately $1,659,408 for FY 75. Again, the CMI system appears to be on target in yielding the cost benefits appropriate to its development.

Computer Costs

It should be noted that for FY 75 and even more so for FY 76 and FY 77 there will be additional one-time computer acquisition and operating costs (see Table 7.6). Such costs have to be amortized over an 8 to 10 year period in order to fully reflect their capitalization in relation to the benefits. Such a process, though, does not reflect the actual outflow of cash. For the Navy CMI system the cost savings ($10.1 M and $1.2 M) more than cover the $1.6 M current or projected costs. Computer based training systems always require this early high start-up cost but within the first four years the crossover curves with conventional instruction are more than dramatic enough to justify such capital investment. For the Navy system, the crossover benefit point has already been reached.

Higher Performance Levels. As indicated in Chapter 3, the students under CMI perform better on the final exam. Therefore, it seems reasonable to assume that when they go to the fleet that they will

Table 7.5

Instructor and Support Personnel Savings

Projected	CI	CMI
Instructor Levels	187 (25:1 for 4699)	83 (30:1 for 2500)
Projected Support Level	292 (12.1:1 x 4699)	206 (12.1:1 x 2500)
Instructor and Support Level for FY75	480	289
Cost	$4,170,240 (480 x 8688)	$2,510,832 (289 x 8688)
Cost Saving		$1,659,408

Table 7.6

Computer Costs*

FY	Cost in Millions
75	1.6
76	2.4
77	6.2
78	3.7
79	2.6
80	2.2

* Total Computer Costs cover ADP personnel, lease purchase equipment, maintenance, communications, and supplies/support.

experience a more positive transfer to on-the-job tasks. Such considerations, though, are very hard to calculate in dollars as to their impact, although one knows it to be positive. For our purposes, it can be estimated that 5 percent of the 10.1 million dollar figure is utilized to derive this benefit ($550,000). It should further be noted that a study of this impact and its real benefit to the Navy should be undertaken in the future.

Student Attrition. Again, the analysis in this area is preliminary at best. The rationale for considering attrition is an awareness that CMI produces a significantly lower rate. It could conservatively be estimated at 4.5 percent or more on the average at 7 percent. If, using the 7 percent estimate, one takes this figure times the total student input for a year for each CMI course and then assumes that a student on the average goes halfway through the course before undergoing attrition, then one comes up with a figure of $56,874 (7% x 2500 x $325) for this cost benefit of reduced student attrition.

In viewing the above cost benefits, one can see that the actual CMI system is performing according to the projected levels of cost savings and perhaps even in a more beneficial manner. (See Table 7.7 for a summary of benefits). The more beneficial factor should be considered by Navy personnel in trying to assess the full cost benefit for CMI. In this way one is in a better position to understand the full implications of all benefits.

Concurrent Navy Operational Benefits. In passing, there are two additional benefits which should be noted. These are very hard to determine costs, and only beginning estimates are provided. First,

Table 7.7

CMI COST BENEFITS	
Goal 1	Reduced Course Time (46.8%)
Goal 2	Reduced Student to Instructor Ratios (23%)
Additional Impact	Reduced student to Support Personnel Ratio (23%)
	Higher School Performance Levels (5%)
	Reduced Attrition (2%)
	Longer Active Work Tours
	Higher Work Performance Levels
	Increased State of Readiness
	Potential for Reduction in Manning Levels

all of the sailors going through these "A" schools have finite tours for which they have enlisted. If there is a 46.8 percent reduction in training time, these number of weeks are added on to their active duty tour. Such additional time provides additional experience for a more knowledgeable, more competent sailor to be performing in the fleet. Such additional time should not be ignored but actually estimated in terms of its contribution and included in the benefits of the CMI system. One can crudely estimate that it is approximately half of the student's salaried savings found within the CMI course, namely $5.5 million or some equivalent additional benefit due to increased competency -- not salary.

Even more importantly, the increased competency due to longer work tours as well as higher competence levels yields a performer who undoubtedly contributes more to the readiness of any given ship. Such readiness permits a reduction in the manning levels for the operational Navy. It is common to hear that many of the career fields which are being trained via CMI are undermanned by official levels. Given that this is truly the case, it indicates that CMI may be contributing to an actual evolving reduction in manning levels for the operational Navy. Again, a benefit of this type is hard to estimate and the Navy ought to study this possible benefit.

Conclusions

1. The Navy CMI system is a highly cost beneficial operation which is saving the Navy during FY 75 in excess of $10.2 million annually ($10.1 + $1.7 - $1.6). Such a contribution is solely due to the effect of the CMI system in comparison to conventional instruction.

Obviously, the costs for the Navy to return to conventional instruction would be enormous, bordering on the impossible.

2. The Navy CMI system yields significant cost beneficial contributions according to all four of its objectives, namely: course time savings, reduced instructor support personnel, higher end of course performance levels, and reduced student attrition. Each of these, if considered, increase the cost savings in excess of $10.2 million for FY 75.

3. The projected cost savings for the Navy CMI system as prepared in FY 73 appear to be conservative at this time and even greater gains can be achieved.

4. The Navy training manager should consider (1) studies of other concurrent beneficial effects such as that attributable to a higher performance level at the end of CMI course and the impact of this factor on transference to fleet operations; (2) reduced attrition and, consequently, higher savings for manpower deployment; (3) increased work times for first tour personnel being processed through CMI "A" schools; and (4) potential for reducing manning levels given increased competency levels due to this improved form of training.

CHAPTER 8. Large Computer Based Training Systems

In the training world, it is a common practice to compare technologically based systems whose purposes are modestly similar with the domain. Such comparisons and contrasts, of course, tend to minimize the differences in stated purposes, objectives, characteristics, equipment, materials, etc. More importantly, they minimize the differential amounts of funded resource levels. Finally, they lack the sensitivity concerning the institutional context into which these computer based systems are implemented. On the other hand, a non-detrimental comparison provides for a clear identification of the alternatives open to large computer based training systems. Such a panorama of alternatives is essential from a training point of view if the beneficial relationships between computer systems design and the resulting training outcomes are to be studied. From an institutional point of view, it is foolish to think that the economics of the computer based training system are not a prime determinant of its current and future implementation. Consequently, the Navy CMI system shall be placed in context with the only two other existing large computer based training systems; this chapter is not intended to criticize or make competitive comparisons but rather to identify the alternatives and illuminate the role of the Navy CMI system with the domain.

In the world of computer based training systems, especially those designed for large groups (in excess of 1,000 students) there are three which can be brought somewhat into the same contextual view. There are large computer based instructional systems in the public sector, e.g., the Chicago Public School Drill and Practice System with

800 plus terminals, and in the industrial training world, e.g., the IBM customer engineering CMI system with 180 terminals, that could be described. The fact that these and other medium sized systems are not described is due not to their importance or future potential, but to their overlap with the PLATO and AIS.) The systems to be reviewed are the University of Illinois, PLATO Computer Assisted Instruction System, the Air Force Advanced Instructional System, Lowry Air Force Base and the Navy CMI system. In order to establish the context and identify the alternatives, the following questions were investigated utilizing interview techniques as well as a study of documents. (In all cases personnel from the University of Illinois PLATO system and from the Air Force AIS have reviewed the write-ups and reacted to them in terms of their accuracy and representation.)

1. What are your current objectives?
2. What is your current computer and terminal configuration?
3. How many terminals are operational in the field?
4. How many terminals can be on-line at a given time?
5. How many courses are on-line at a given time?
6. What is your current maximum number of students on a given day?
7. How many terminals do you project for 1980?
8. What is your mean systems response time?
9. How many transactions per terminal per minute do you normally observe?
10. What is the character size of a typical course?
11. How long is a lesson and a course on the average?
12. What procedures do authors use to implement a course?

13. How many authors currently are active?

14. What type of instructional model (total displacement of instructor, supplemental, or impact) do you have for your classrooms?

15. What effect is your system having on your institution?

16. What institutional changes are facilitated?

17. What institutional changes are inhibited?

18. What is the current cost of your terminal?

19. What is the cost of your computer configuration?

20. What is the cost of your communication multiplex equipment?

21. What will the operating system and language cost?

22. What is your authoring to lesson hourly ratio? (This query assumes the full ISD process through computer implementation. Unfortunately, the estimate may be truncated.)

23. Is there an instructor reduction planned for the system and institution?

24. What reduction in course time are you observing?

25. What are the unique features of your system, and what are its greatest benefits?

For the purpose of communication, the answers to these questions will be found in the following narratives. A narrative descriptive style is being used in order to promote understanding and minimize any invidious comparison or focusing on one comparative element to the exclusion of all others.

The PLATO IV Computer-Based Education System

The PLATO system, currently under R & D expansion by the Computer-based Education Research Laboratory (CERL) at the University of Illinois, is designed to provide high quality technologically-based education at low cost. The system was developed initially in the Coordinated Science Laboratory, under the direction of Dr. Donald Bitzer. A Control Data Corporation Cyber 73-74 (6700) is the central core control element in PLATO which allows for a large number of students, at various institutional levels and over a range of disciplines, to receive instruction simultaneously.

Objectives

Although the program objectives for PLATO are not documented at present, Dr. Bitzer views them as encompassing three general domains: technical, educational, and research. Underlying all the objectives is one general goal: to develop low cost, computer based education which will be easily accessible to the general public. The achievement of this goal presupposes the attainment of several sub-objectives, many of which are considered to be unique to the PLATO system.

(1) The effective use of television channels for data distribution. At present PLATO employs a microwave delivery system capable of transmitting information to terminals within a 20-mile radius of the University of Illinois. The communications cost is now estimated to be lower than commercial telephone services.

(2) An increase in terminals per phone line capacity. The current PLATO system can serve terminals up to 1200 baud telephone lines. It is anticipated that within one year, this capacity will be increased so as to accommodate at least eight terminals per line.

(3) Improved technical terminal design cost outcomes. The PLATO system currently utilized a plasma display terminal. Advancements

in engineering technology and an anticipated demand that supports mass production should result in costs being reduced by one-fifth.

(4) <u>An increase in the processing memory program configuration</u>. A proposed enhancement of the CPU/ECS configuration yields the potential of reducing cost for servicing a users.

(5) <u>To develop a nationwide/international network</u>. While the present PLATO system is not expected to increase beyond a projected capability of driving approximately 500 terminals, it is anticipated that other PLATO systems of similar size will be implemented both nationally (e.g., Florida System) and throughout the world. These systems will be interconnected via phone lines allowing for a rapid and cost-effective transfer of both techniques and course-work.

The educational objectives of PLATO, of course, are integrally related to many of the technological goals classified above. The most basic objective in the educational domain is to increase the usage of PLATO by public schools, community colleges, universities, and military training systems to approximately 5,000 hours per day. By way of comparison, it is estimated that roughly 2,000 hours of instruction are being utilized today.

The dynamic mission for PLATO dictates the need for an ongoing R & D effort to evaluate the existing system and determine what changes might be implemented to reduce costs and enhance instructional capabilities. Future R&D will be focused on questions such as: "For which courses does the PLATO system appear most appropriate?" "What different types of instructional services ought to be provided?" "How can PLATO be made more accessible to the private sector of the country?"

Computer Equipment

The display unit used by PLATO is the "plasma display panel," which consists of two thin, transparent sheets of glass on which are placed 512 horizontal and 512 vertical transparent conductors. This technology makes possible graphical display capabilities, selective write and erase of parts of the display without disturbing the rest of the screen, design of symbols, standard alphanumerics, animation, and rear-projection of color macro images onto the panel. The plasma model is considered to be highly cost-effective (current custom price is $6500 plus add ons) and well suited to low-cost mass production.

The display unit is incorporated into a sophisticated student terminal which contains a special key set, a random-access image selector used for the rear projection of color micro images, a touch-sensitive device, and input/output parts to operate external equipment under computer control. Among other devices used with the PLATO IV terminal is a computer-controlled music box which can be used to transmit tunes of varying pitch and duration. The PLATO IV terminal is regarded as a highly innovative and technically sophisticated device with capabilities that far exceed those of other terminals presently in existence. (Some DOD users have found micro image projectors to be marginally reliable in terms of image placement on the screen, e.g., Trident CBI Study.)

The computer to which the PLATO terminals are connected has 65,000 60-bit words of central memory, two central processors (CPU's), several disk storage units, and ten peripheral processing units (PPU's). The heart of the system is the CDC Extended Core Storage unit (ECS).

Permanent storage of lesson material is on the disk units, but a requested lesson is transferred to the ECS unit where it remains while in use.

Current and Projected Utilizations of PLATO

At present there are between 850 and 900 terminals participating in the PLATO System. However, it is estimated that the system, as it now stands, can accommodate a maximum of 550 terminals at one time. Approximately 480 terminals are supported now (the exact number is displayed on all terminals by the system). Given 480 terminals institutionally distributed to schools and community colleges NSF sponsored - 39 percent, DOD groups - 11 percent, universities - 10 percent, and the University of Illinois - 40 percent, the current potential for instruction is estimated to be 4800 students (currently estimated at 2,000). Approximately 4,000 course hours, encompassing university, community college, public school, and military programs, are now on-line. Over 120 disciplines are represented in the university-related courses. The exact number of students who use the system is unknown, but it is estimated that on a typical day, there are approximately 2,000 student users. An average lesson for accredited university courses is one hour in duration, whereas for elementary instruction, lessons range from 15 to 40 minutes. Each course contains approximately 30,000 6-bit characters per hour of instruction. Three types of classroom models are most pervasively employed -- Supplemental, Impact, and Displacement. (The Supplemental model is a form of instruction that aids a more conventional ongoing instructional purpose; mathematical drill and practice in the elementary school is an excellent example of such supplement. An Impact application is the application of technology to bring about a change in the instructional process and institution and enhance the beneficial outcomes. The Navy application of computer support of individualized instruction is an example of such impact. Total Displacement is the CAI tutorial conception advocated in the 1960's and foresaw that most or all of education could take place by a technical means as opposed to a more conventional human interactive process.) Dr. Bitzer feels that the most effective application of PLATO appears to be with the Impact model.

A very desirable feature of PLATO is the rapidity with which communications are delivered to students. The average systems response time is 130 milliseconds, and roughly 30 transactions per minute are expected.

Projecting to the future, the PLATO group anticipates that by 30 June 1975 the number of operative terminals will increase to 960, with the goal being an additional increase to 2,000 terminals within the next few years. Although the University of Illinois system is not expected to extend in capacity beyond 2,000 terminals, it is assumed that by the 1980's similar PLATO systems will be implemented throughout the world. Thus, it is quite possible that in 10 years time there could be as many as 100,000 PLATO terminals in operation. These could serve literally millions of students.

Authoring Procedures

All authoring is performed exclusively through the terminal by use of the TUTOR language. TUTOR can be characterized as a highly powerful and efficient CAI language, relatively simple to learn, and rich in its communicational (instructional) capabilities. (Some DOD authors have observed that TUTOR is concept-oriented and limited in full file handling abilities.) It is generally assumed that most instructors, with some assistance from CERL consultants and on-line lesson-writing programs, can acquire considerable fluency in authoring courses in a fairly short period of time. In fact it has been observed that the highest quality materials are produced when the instructor themselves, rather than professional programmers, do the authoring. There are approximately 1,000 authors, including students, currently active in the University of Illinois system. For experienced authors, the programming to lesson hourly ratio is estimated to be in the neighborhood of 40-50:1. (DOD experience at NTC, San Diego, indicates that this ranges from 100 to 250 hours per lesson hour.)

Cost Figures

Estimates of the cost figures for the major components of PLATO are as follows: Display terminal - $2,000 ultimately, currently $6,500+; Computer - $13.5 M (Computer $8 M and terminals $5.5 M); Language/System - 30 man years (30 man years x $20 = $600,000); and Communications/Multiplex equipment - $150,000 per year.

Benefits and Implications

At the present time, no instructor reduction is foreseen as a consequence of utilizing PLATO, although a significant reduction, if desired, would certainly be possible. Instead, the benefits derived from the PLATO system are being translated into increases in teacher-to-student ratios. Since the PLATO system can deliver instruction to a large number of students with relatively little increase in cost, university courses can expand in number and enrollment without the requirement of employing additional faculty. The potential savings in cost is, therefore, considerable. (This remains to be achieved.)

With respect to time savings in learning, little evidence is presently available since the majority of PLATO instructors structure their courses according to conventional classroom schedules. The few examples of self-paced courses which have been implemented suggest that time savings as great as 33 percent may be realized.

In summary, the PLATO system appears to comprise an effective and relatively inexpensive approach to educating large numbers of students. It encompasses many unique features, the most significant of which, according to Dr. Bitzer are:

(1) The TUTOR language, which is rich in its capabilities although one observes a wide range of reactions by authors.

(2) Multi-media Capability, which is made possible via the plasma screen terminal. The terminal is at the heart of the system and is its greatest benefit.

(3) Overall Philosophy toward CAI, which avoids formal management structures and labor differentiation (writers vs. coders) while supporting a total systems approach on the part of developers, engineers, administrators, authors, etc.

Air Force Advanced Instructional System

The AIS system grew out of a realization that a total systems approach was essential to address the comprehensive requirements of

Air Force educational and technical training. The AIS evolved from a concept first developed in 1966 by the Instructional Technology group at Hq. USAF. In 1969, the Lowry AFB Human Resource Laboratory, Technical Training Division, assumed responsibility for this advance development program and began the formal justification and planning process. Recognizing the primary driving force of cost-effectiveness in technical training, the AIS was designed to be primarily an operational computer supported instructional system (CMI) with a powerful R & D capability for complex training. The planning effort was extensive, in that a systems engineering approach was followed in using standard DOD 1379 planning techniques and evolved through a number of iterations. For example, the project recognized the necessity of segmenting the system into sub-system requirements of which there are seven: (1) instructional materials; (2) instructional strategies; (3) media; (4) computer software; (5) computer hardware; (6) personnel and training; and (7) related requirements (for example, reliability, maintainability, and human factors).

Objectives

The AIS is an artful mix of operational and research objectives. These are reflected in their stated goals as well as their specific measurable objectives. The dual goal for the AIS was to develop a cost-effective computer based instructional system for four ATC courses (students AOB = 2100) and to provide a facility for the exploration of parameters and research alternatives that will contribute to Air Force training and education. This general goal was further broken down into the following subgoals:

(1) Adaptiveness. The AIS shall provide procedures for facilitating student individual differences according to the utilization of appropriate training algorithms to specify specific strategies.

(2) Flexibility. The AIS shall offer a sufficient array of training alternatives so as to provide for both cognitive and performance requirements as well as individual and multi-person behaviors.

(3) Expandibility. The AIS is designed to provide for variations in student flow, number and variety of courses, and varied locations while supporting individualized approaches that specify prescriptive learning, adaptive testing, evaluation, and cost optimization.

(4) Modularity. The AIS is designed to provide for both the preparation and revision of course materials so as to more adequately meet changing training requirements.

(5) Cost Effectiveness. The AIS shall demonstrate significant reductions in course length, stable (no increase) elimination rates, and improved end of course performance. All of the above goals presuppose the availability of a rich array of off-line media alternatives as well as the necessary computer support.

The above goals have been translated into more specific objectives. These give a more measurable array of progress which the AIS can pursue.

1. The AIS shall offer a significant cost savings. A 25 percent reduction in course length and an appropriate reduction in instructional staff and resource as well as the future capability to provide for the all-volunteer force, reduced manpower, and expansion capabilities.

2. The AIS shall demonstrate the ability to train students to the ATC specialty standards and according to ATC evaluational procedures.

3. The AIS shall be interfaced to the non-training parts of the training environment, for example, recruitment personnel and base facilities.

4. The system shall be usable by Air Force personnel as a tool for converting other courses to presentation on the AIS.

5. The AIS shall be expandable or replicable to meet a wide spectrum of Air Force training and educational requirements.

6. The AIS shall collect training data to form the basis for its own evaluation and improvement.

7. The system shall be capable of supporting exploratory efforts to develop and evaluate new training technologies.

Any of the above objectives could be expanded at great length. Each is being pursued diligently by the Air Force through its AF HRL/TT Division, ATC personnel, and supporting Air Force units, as well as a $10.8 million contract with the McDonnel Douglas Corporation (as will be explained, the $10.8 million provides for the acquisition of the computer and media hardware as well as the development of significant software and wide-spread course conversion).

Computer Equipment

The computer is a CDC Cyber 74 with 65,000 60-bit words of central memory, 500 K words of extended core storage, 10 peripheral processing units (PPU's), several disk storage units, standard input-output devices, and a flexible communications system (telephone and video links). The initial prototype shall have nine to 16 CMI terminals with enough computer capability to support up to 50 CMI terminals without system response delays. A CMI terminal consists of an optical mark reading device capable of inputting standard test scoring sheets, and a 240 character/sec. chemical heat printer plus a mini-computer controller.

According to the design plan there shall be about 50 to 75 plasma panel interactive terminals having the general characteristics cited in the PLATO description except that a new rear projection method is yet to be implemented.

From a computer hardware point of view the AIS is essentially equivalent to, but slightly scaled down from, the University of Illinois PLATO configuration. Obviously, there are significant differences, however, in the software given that the AIS supports CMI terminals; this represents a highly significant difference in the systems. Given the likelihood of an extended future, one can also anticipate that various experimental simulator devices will also be incorporated within the system, depending on R & D outcomes.

Current and Projected Utilization of the AIS

At present the AIS is still in its initial implementation phase. The majority of the Inventory Management/Materials Facilities course, which represents nearly 50 percent of the AIS student load is proceeding in Instructor Managed Instruction (IMI) mode. There is now a limited on-line computer support of test scoring, however, all other test data is batch entered into a data base reflecting the learning and performance levels of the students. This is entered via usual CMI administrative procedures. The plans call for rapid application of computer support during the early portion of the coming fiscal year. Both the application of adaptive testing and adaptive instructional modeling shall receive the preliminary feasibility evaluations during the first half of the fiscal year.

The prototype system shall support 700 students within a given 6 hour shift or 2100 students daily. The average lesson shall vary from about 15 minutes to three hours with a mean approximating 60 minutes. These estimates may change as greater experience is gained concerning the actual application of CMI procedures. At this time it is premature to estimate the number of characters per hour of instruction within any given course. As to classroom models it is anticipated that the AIS will be a mixture of the impact and displacement models. It is impact in that it changes the AF institutional training processes. A transition plan that incorporates change procedures is a specified requirement. It will be displacement in that significant functions like cognitive learning and testing shall be completely under computer control.

The operating characteristics of the AIS will undoubtedly be highly similar to that of PLATO. It is anticipated that the average system response time shall be less than 250 milliseconds for interactive programs. An average of 2.0 transactions per minute on the CMI terminals and 60 transactions per minute on the CAI terminals shall be expected. In terms of the future, the Air Force is currently studying the requirements for expanding the current AIS to support instructional development at a number of bases throughout the continental United States. In addition, one can anticipate a serious evaluation of its applicability and dissemination to all of the technical training centers currently operating within the Air Force (there are five of these in number). Therefore, one can anticipate that the AIS could be disseminated broadly throughout the Air Force as well as the DOD training world. For the 1980's the computer system has the capacity to expand to several hundred CMI terminals and several hundred interactive terminals (given an upgrade in the hardware). Initial on-line usage of CMI terminals shows that about 120 transactions per hour can be handled per terminal. The actual number of students handled per terminal per day depends on the interactive rate built into the curriculum.

CAMIL/Authoring Procedures

The major effort within the AIS project is the development of a new language capable of achieving a number of highly operational objectives. First and foremost, the language is being designed and implemented to be of easy use and applicability to instructional systems development and operation. Second, the language represents the application of the latest concepts in computing science. For example, CAMIL statements represent a natural language, sentence-like structure. Each sentence in turn, can allow for embedded sentences, similar to those found in the English language. At the same time all of the power and capabilities of the operators found in such languages as APL, Fortran and Cobol are present. An additional software feature is an integrated file handling system which provides an on-line management information system (MIS) to support adaptive instruction.

This should allow the CMI course managers to adjust parameters and flow within the course to achieve additional efficiencies and enhanced learning outcomes. Since the language is still in its prototype operational stages, many of the common estimates cannot be made. For example, it is inappropriate to estimate how many authors are presently using the language or what the programming to lesson hourly ratio seems to be.

Cost Figures

Many components are still under acquisition and development so that the following cost figures are a preliminary estimate: CMI terminal - $18,000; CAI terminal - $9,200; computer - $1.9 million; software development (30 man years x $50,000 = $1.5 million), and communications equipment - $150,000. It should be pointed out that the above cited costs represent an indeterminate mixture of operational requirements and research. Undoubtedly, as the AIS matures and is disseminated, a much lower capital expenditure would be yielded.

Benefits and Implications

Similar to the PLATO system at this time, it is difficult to estimate the instructor reduction possible through the AIS. On the other hand, the goal of a 25 percent reduction in course length is being achieved using the overall technology of the system. (A 40 percent reduction is presently being achieved in the Inventory Management/ Materials Facilities course.)

In summary, the AIS is in the early stage of its implementation. Its full benefits and potential are yet to be determined. This system could easily prove to be the most optimal approach to the overall training in the DOD environment in that the system allows for an appropriate mixture of CMI and CAI capability. Such a mixture is an obvious requirement if one considers the complexity found within technical training, especially as it advances toward the actual weapons system training stage (experience with the S3A System indicates that CAI is a highly beneficial simulation training approach).

Navy CMI System

Since this monograph has exhaustively described the Navy CMI system in terms of its past, present, and future, this section shall only provide a summary. The purpose of the summary is to answer the above stated questions and provide the reader with some understanding of the differences of purpose and level of development.

The Navy CMI system has been designed to enhance the dissemination of individualized instruction throughout the Navy technical training world. The primary thrust is individualized instruction; CMI is a supporting system to this rapid dissemination. In this regard, CMI can be considered an impact strategy in that it has allowed for the rapid change of many of the technical schools within the Navy community.

Objectives

As cited in prior chapters the Navy system has four objectives: (1) a 30 percent reduction in course length; (2) a 20 percent reduction in instructor and supporting staff personnel; (3) an improvement in student performance on end of course examinations and (4) a reduction in within course student attrition. As cited in Chapters 3 and 7, the Navy is currently achieving all of these objectives. In addition, the Navy is committed to enhancing the system in utilizing any instructional strategy that effectively contributes to the above four stated objectives. Therefore, one can anticipate the evolution of new instructional strategies to achieve even greater benefits during the coming years (see Chapter 9).

Computing Equipment

The Navy has a Honeywell Series 60 computer with two CPU having 131K-36 bit word cores. Eight large disks (117 M characters each), six tape drives, and state of the art 1/0 components make up the configuration. The multiplexors are mini computers capable of local support, line switch, and telephone oriented transmission. The design maximizes system reliability.

The CMI terminal is composed of 120 CPS keyboard/printer and an Opscan 300 sheets/min optical reader. The administrative terminal is composed of a micro processor/message switcher (with a disk), a 300 LPM printer, and a 600 CPM card reader.

As to cost, the GSA schedule for Honeywell can be consulted and it indicates an approximate 30 percent discount. The estimated hardware cost for lease purchase is approximately $8 M for the six year life cycle.

Current and Projected Utilization of the Navy CMI System

The Navy system is planned to have nearly 17,000 students participating on a daily basis by 1980. As indicated in Chapter 7, this represents approximately 20+ courses. Obviously, the Navy has selected its highest student flow courses for inclusion in this activity, and one can anticipate that as it matures even some of the medium flow courses can also be incorporated. Analysis of the above equipment indicates that it could grow substantially beyond the targetted level.

In reference to lessons, the current CMI system encodes the grading of tests and the next prescriptions. Typically these represent about 3,000 characters per lesson. The system response time shall have a mean equal to or less than 30 seconds. It is anticipated that two transactions per minute shall take place at each CMI terminal.

Authoring Procedures

Authoring procedures are an off-line activity with input taking place by cards. As indicated in Chapter 4, the language is highly specific and requires a comprehensive orientation to the system in order to be able to cope. Fortunately, since the majority of the learning materials are off-line, specialized individuals can do coding in a very rapid manner. It is currently estimated that the programming to lesson hourly ratio is approximately 30 to 1. (This figure includes textual media conversion as well as computer activity.)

Cost Figures

The following estimates are provided for the components for the Navy CMI system: CMI terminal - $9,000; computer - $2.5 million; language - 5 man years x 40,000 = $200,000; computer and multiplex equipment - $300,000.

Benefits and Implications

The Navy system, as illustrated in Chapter 7, represents a highly beneficial approach from a cost point of view. In addition, the performance data indicates that it has an acceptable to enhanced level of effectiveness. The desired reduction in teacher to student ratios of 20 percent has taken place. The targetted 30 percent reduction in course time has been exceeded and presently resides at 46.8 percent. It is anticipated, though, that this figure will drop slightly as more courses are brought aboard.

In summary, the Navy CMI system appears to have many advantages from an operational point of view. Given its background and growth from an R&D effort, it has allowed for appropriate expansion and dissemination throughout the Navy technical training world. This process will have to continue over the next few years for the ultimate benefits to be achieved.

Conclusions

1. Each of the three computer based systems described have important and unique purposes, goals, and implementation characteristics. In essence, both the operational characteristics and component cost factors clearly document that each of these three systems should be continued and monitored in terms of their ultimate contributions to large training requirements.

2. The Navy CMI system represents one end of the continuum which maximizes on the training of large numbers, in fact, eight times as large as the nearest system and has the potential to support even

larger numbers. Given the requirements for cost savings through centralization, it seems only natural to watch the expansion of the Navy system towards its goal of nearly 17,000 students and on upwards to two or three times that number. Such an approach, of course, may require the consideration of tri-service sponsorship of the system and application.

3. Given the cost factors and current savings, it seems appropriate for the Navy CMI system to consider exploring further sophistications in its training strategies in order to thoroughly explore the full boundaries of its potential impact and cost effectiveness.

CHAPTER 9. Future Development For Navy CMI

The purpose of this chapter is to explore some of the possible new instructional strategy alternatives open to the Navy CMI System. The purpose of this exploration is to identify training alternatives which would enhance the cost/beneficial impact of the Navy CMI system. Obviously, any alternative which cannot be documented in at least an advanced development sense, or has a high likelihood of improving the current CMI system, should be held in abeyance until further evidence indicates its preliminary implementation or rejection.

Given the success to date of the Navy CMI system in terms of achieving its objectives and its cost/beneficial outcomes, one could raise the question, "Why implement new alternatives?" There are two very persuasive reasons. First, technological systems tend to overachieve themselves at times. For those that are creating a major breakthrough, even further benefits can be achieved by appropriate enhancements of their approaches and the domains of activities they enter. For Navy CMI this would indicate a further investigation of not only enhancing instructional strategies, but also the kinds and types of course it supports. Secondly, it is common for technologically-based systems to undergo repeated cycling between research and on-going operations. The research and development activities act as a stimulus to further fine-tune the CMI systems. Given the amount of DOD money being currently invested in basic research (6.1) and advanced development (6.2), especially in the area of computer-based training, it would seem ill advised not to continually survey the outcomes of this effort and consider the possible incorporation of some of these developments within the Navy CMI system. Obviously, consideration of these alternatives should be determined by whether or not they meet an appropriate set of criteria.

The consideration of criteria for preliminary implementation of a new instructional strategy or associated training technique within the CMI system requires extensive analysis, assessment, and policy determination as to their impact on the on-going operation. The following criteria seem appropriate for the consideration of new alternatives:

1. The new training alternatives should represent a significant contribution to the reduction in cost and the enhancement of the training outcomes for the CMI system.

2. The new alternatives should not disturb the on-going operation or make excessive modification requirements, but rather should fit into the on-going operation in the form of an extension or further enhancement of the on-going computing system.

3. The new training alternatives should have a sound experimental base; therefore, the connections with the Navy's basic research capabilities should be obvious and direct.

4. The new alternatives should be consistent with and supportive of the mission of Navy training.

Given these or more refined criteria, two major trends of research prototypes are appropriate for consideration by the Navy CMI system. The first of these relates to the enhancement of the instructional strategy process; the second relates to supporting the institutional ISD process and personnel. Each of these shall be considered in turn.

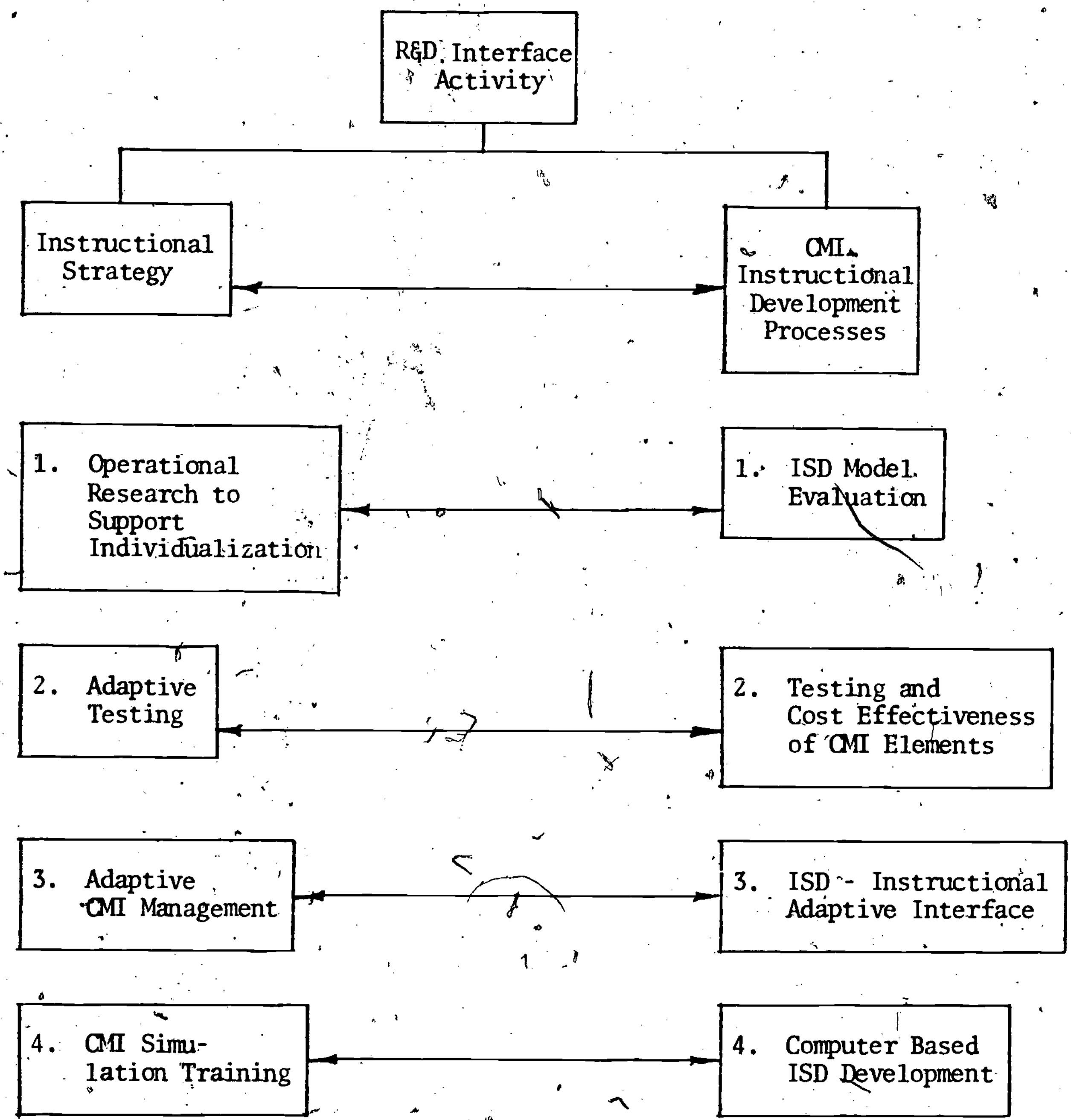
For each considered trend (instructional strategies and ISD processes), there are cumulative interrelationships at each stage. For example, each stage assumes the existence of its parallel element and shares data and findings. Second, each will require computer software enhancement that will support each in a common manner. Finally, the eight considered R&D elements mutually support each other in a fashion that should lead to a vastly enhanced CMI system. (Obviously, each considered R&D element qualifies according to the four above criteria; each would require planning and detailed designs to be implemented.)

9.1 Instructional Strategies

Instructional strategies can be defined as the development of training resources so as to appropriately create a sequence and environment for a given student so that his learning and performance is maximized. From this frame of reference, there are four obvious stages through which the CMI system could appropriately develop in terms of its enhancement and growing sophistication. These are as follows: (1) operational research to enhance individualized learning, (2) adaptive testing to improve the measurement process while reducing testing time, (3) adaptive management of the system so as to dynamically match resources with student requirements, and (4) complex training through simulation. Each of these will be discussed in turn.

1. Operational Research to Enhance Individualized Learning. The application of operational research techniques plus the development of operational learning feedback mechanisms have proven powerful in both

Figure 9.1: The Interface of R&D with the CMI System



management and training systems. While the CMI system has the existing capabilities to provide masses of data potentially useful to LCS's, course managers, and instructional designers, there appears to be an unfortunate limitation in the instructional diagnostic reporting capability. This deficiency may be largely due to an emphasis on the individual student in his everyday instructional progress to the exclusion of learning characteristics of groups of students within the system. Thus, the available data are not systematically stored or organized so that they may be retrieved with their full interrelationships and implications. For example, performance times are accessible, but without reference to the categories of students or specific segments of content. While these data are available on an individual basis, no provision has been made for group or system implications so as to monitor group progress and fluctuations over periods of time. Moreover, the current data do not adequately address the characteristics of levels of difficulty of lesson material, appropriate assignment of media, and the effects of remediation. Therefore, an operational research thrust should be pursued which on the one hand, attempts to gain more information on groups of students and at the same time looks at implications for significant instructional strategy elements. This is the main focus of this initial stage.

Within the DOD training research world, there is extensive evidence to indicate that assessment of functional reading, learning styles, instructional adaptation indices, information processing indices, and incentives can provide significant insights into individual and group behaviors, both from current progress and predictive points of view. It is proposed that these existing tests be given to sufficient size sample of Navy students and then be related to data concerning the level of learning difficulty, assignment of media, and remediation. Simply, an individual, by group, by instructional strategy data cube should be formed which shall allow for better insight into the assignment of students, rather than continuing the voluntary student self-selection strategy currently found in Navy CMI. Such a system of assignment has yielded enhanced performance in the 10 to 20 percent range. While there is limited evidence concerning reductions in course learning time, there is an obvious relationship, and one can anticipate at least a five percent time savings. Therefore, this operational research stage appears to have great benefits and should be aggressively pursued.

2. Adaptive Testing to Improve the Measurement Process While Reducing Testing Time. One of the key components within Navy CMI is the systems testing of the students' performance upon completion of each module. The time devoted to this activity varies between 18 and 25 percent of the total time spent by a student in a course. Given such an extensive commitment to measurement, the application of adaptive testing techniques appears appropriate. Adaptive testing, especially when implemented over an individual terminal, has yielded better than 50 percent reduction in testing time. Given the nature of the equipment, it is proposed that a pilot study investigate the application of adaptive testing techniques to the existing batch oriented CMI terminals as opposed to individual CRT terminals (it should be noted that no enhancement of equipment would be required in order to pursue such a pilot study). If it can be documented that

batch-adaptive testing is equivalently effective in terms of time savings, such a procedure could be implemented with little or no cost to the current system. Such an assertion as this is possible in that the actual procedure for assigning tests can be adjusted to adaptive techniques with little effort.

3. Adaptive Management of the System so as to Dynamically Match Resources with Student Requirements. Adaptive management refers to the twofold application of optimal allocation of resources, such as learning center supervisors' time or laboratory equipment, according to the individual and group parameters found for the students. At the present time, the Navy CMI system presents the same prescription to all students, given their equivalent progress through the course. It is proposed that further individualization could take place, while preliminary research is still underway (NAVPERSRANDCEN/MSU Study of Adaptive Instruction). In addition, a dynamic scheduler for critically costly resources, be these human instructors or simulators, can insure better utilization of these resources within the Navy training environment. It is on this basis that it is recommended that the Navy CMI system pursue this line of development along with the other two branches of the service (this is an active part of the Air Force AIS program and the Army CTS System).

4. Complex Training Through Simulation. During the past decade and one-half computer driven simulators have become a common phenomena in all forms of military training. Unfortunately, the cost of a weapons system-like simulator, in many cases, exceeds that of the weapons system itself. Therefore, it seems appropriate to enhance

the Navy CMI system in the long term so as to operationalize those aspects of simulated training appropriate as a precursor or follow-up to the availability of the actual equipment. Simulated training on the S-3A or in the preliminary TRIDENT training study indicates the power and cost effectiveness of such a CBI approach. Given that this is the fourth stage in the trend, it is anticipated that further results over the next two or three years will contribute significantly so that once the Navy CMI system embarks on such an endeavor, it will firmly proceed based upon training research findings.

9.2 Institutional ISD Processes

The interrelationships between CMI and Instructional Systems Development (ISD) processes are both extensive and in many respects undocumented and/or unexplored. The goal of this second trend of research will be the clarification and the empirical evaluation of the ISD processes as they interface with CMI requirements. This effort should lead to a better definition of the actual interface requirements and provide clearer cost effective techniques and methodologies for facilitating investigations of this critical developmental area. Given an understanding of the current CMI system and its likely developments in the future, the following four stages are offered within this ISD developmental trend as follows:

1. ISD model evaluation for CMI requirements
2. Testing of the cost effectiveness of CMI elements
3. Adaptive interface of the ISD - instructional process
4. Computer based ISD development

It should be pointed out again that each of these stages not only contributes sequentially, but are interfaced with the instructional strategy for parallel stages, that is, the operational research will feed in directly into the ISD model evaluation and CMI requirements. In turn, adaptive testing provides the basis for fine-grained analysis of the CMI cost effectiveness. Adaptive management leads directly into a consideration of adaptive ISD instructional interfacing. Finally, training simulations are of the same complexity and sophistication as computer based ISD development.

ISD Model Evaluation for CMI Requirements

During the last five years, Navy training has created and propagated significantly new instructional systems development models for the creation and updating of curriculum and associated training materials. These models profited extensively from prior research work in task analysis. From the beginning the Navy CMI project has interfaced and utilized Navy ISD personnel for the conversion and development of CMI courses. The requirement for building a bigger pool of expert manpower is obvious and critical. At the same time ISD models have remained relatively unevaluated in terms of each component's output (it should be noted that the overall effect of the ISD model process has proven to be highly effective). When two major systems, namely, ISD and CMI are required to interface, it seems appropriate to evaluate the ISD model in terms of its contribution to this CMI effort. The focus of this first stage of research study is to empirically document the contributions of Navy technical training ISD and courses as they undergo conversion. This documentation will be in terms of the manpower employed, the procedures utilized, and their ultimate effectiveness within the CMI operation. Utilizing data from the operational research stage in the instructional strategy trend as well as specially collected data, one can anticipate that those ISD components most critical to the CMI requirements can be identified.

Testing of the Cost Effectiveness of CMI Elements

As reflected in this monograph, the cost effectiveness of Navy CMI is outstanding. Unfortunately, the contribution of various components remains to be established; for example, is it the ISD process that is contributing the most to this effectiveness, or is it the testing and prescriptive process? One hears many advocate the student tracking and projection incentive techniques as being at the heart of the impact of the CMI system. The thrust of this endeavor shall be to utilize data from operational research and adaptive testing in assessing the effectiveness and contributions of each of the CMI elements. Critical base-line data shall be utilized as the instructional strategies evolve so that component effects can be isolated. It will also be important in terms of the relationship between ISD personnel and instructional personnel, our next research stage.

Adaptive Interfacing of the ISD Instructional Process

Chapters 5 and 6 spoke to the specific functions and relationships of both the Learning Center Supervisors and the ISD personnel. Unfortunately, the interrelationships between these two groups have been informal. The exact communication and purpose of the communication is yet to be documented. For example, should the ISD personnel be preparing materials to be utilized by the Learning Center Supervisors as they undertake new functional roles? If the LCS's were given even broader alternatives for remedial tutoring, personal counseling, and application of human resource concepts within the context of technical training, what types of materials should be prepared by ISD people? In essence, the focus of this study is to identify appropriate relationships between ISD personnel and the Learning Center Supervisors. This mutually facilitating interrelationship will be tested by having new functions evolve for selective, lead LCS's and evaluated in terms of the support of the ISD group as well as the LCS's abilities to accept and expand their functions. The intent is not to redefine roles but to enhance them. This is predicated on the fact that each of the groups expressed, to varying degrees -- the LCS's more so, the ISD personnel less so -- their worth or their significance within their activities. By enhancing their roles and applying a proper utilization of leadership management techniques, one can anticipate significant increases in effectiveness.

Computer Based ISD Developments

During the past decade, the utilization of a computer for curriculum development has been proposed by a number of leaders and groups. The preliminary attempts at such places as Florida State University and Stanford University have proven to be quite promising. Within the DOD community this activity has been limitedly explored at NPRDC. Therefore, it seems most appropriate to propose it as a culminating sophistication for the Navy CMI ISD trend. What is being proposed is the utilization of computer terminals for the actual planning, authoring, pilot testing, and formative evaluation of materials prior to their use in more conventional off-line purposes within CMI. The argument put forth is that this should provide faster development of materials as well as more detailed formative evaluational documentation and substantiation. If this is really the case, this type of computer utilization could become a highly important function of the Navy CMI system and should not be considered supplemental or supportive in nature. Curriculum creation and especially revisions is an extremely costly process. If computer based developments could facilitate both the timing and cost aspects, this would be a major breakthrough in the DOD training world.

9.3 Conclusions

1. Given the R&D and extensive, successful, growth of the Navy CMI system, the further enhancement by proven research prototypes and findings should be pursued so as to broaden the impact of individualized training.

2. The selection and implementation of R&D prototypes should be based on rigorous criteria and the high likelihood of enhancing the cost effectiveness of the system.

3. The considered elements of instructional strategies and Instructional System Development activities appear to be the most likely candidates for implementation.

CHAPTER 10. Summary of the Navy CMI Study

The Navy CMI System represents the most outstanding large computer based individualized instructional system to date. There are many reasons for this outstanding Navy achievement. First and foremost, the training effectiveness found within this system has been and continues to be exemplary. The logistic achievement of supporting in excess of 3,000 students represents a first in this field. More dramatically, the cost beneficial outcomes yielding a savings of $10.2 million during FY 75 are rarely found in the beginning life cycle of a training system. Finally, the Navy CMI system has provided for effective institutional integration so that its implementation has patterned into the common practices and styles of Navy technical training while achieving its own unique benefits.

The MSU study team utilized a number of different methods in the preparation of this monograph. First, documents, both past and current, were utilized to develop a general framework. Most importantly, interviews with significant designers and Navy managers were held (without the support of all of the Navy and civilian personnel, this monograph could never have been drawn together). Survey techniques were utilized in gathering the data concerning the learning center supervisors and the ISD personnel. Finally, the CMI system provided computer analysis which documented its own effectiveness. Such computer analysis concerning its operation is considered a sine qua non for any computer based training system.

The development and performance data yielded to date by the Navy CMI system provides its strongest quantitative argument for supporting the expansion of its outstanding capability. First, the CMI system has yielded significant course reductions ranging from 24 to 80 percent with a mean of 46.8 percent. This, in turn, has yielded a $10.1 million saving in student salaries. Second, the effective reduction in the number of on-board students has allowed for an associated reduction of 23 percent in instructional/support personnel. This yields a savings of $1.7 million. Third, the CMI training approach, yields significantly better end of course performance levels while the attitudes of students tend to be more positive. The cost beneficial effects of this factor are yet to be precisely determined. In turn, the CMI system tends to significantly lower the attrition rate to between 4.5 to 11.1 percent in magnitude. This yields approximately $550,000 in savings for FY 75. Finally, the computer implementation, both as currently operating and in terms of the acquisition of the Honeywell system for expansion, has yielded significant savings both in terms of the competitive procurement as well as the potential for expanded capability. For these quantitative reasons the Navy CMI system can be judged to be the most effective, large-scale, computer based training system to date.

In terms of the institutional training processes, the CMI system has effectively integrated itself within both personnel and operational procedures. For example, the learning center supervisors as well as ISD personnel perceive CMI as the best approach to individualizing the training process. Each of these groups are highly committed to its successful implementation and operation. This is then reflected in the high positive attitude of students toward both their learning center supervisors and CMI. Given the high involvement of the Navy uniform personnel in this implementation effort, all of the personnel perceive the challenge that CMI presents and recognize the advantages of the system, its effective time savings and instructional objectives. In comparison to other computer bases instructional systems, involved personnel have significantly better attitudes.

As noted in the early sections of the monograph, the Navy system also represents an outstanding example of how R&D activity culminates in fruition of an actual training operation. The research climate, shared civilian and uniformed personnel, a commitment to sound training design, and an adaptive approach to CMI systems goals undoubtedly allowed it to move from the R&D phase to full operation in less than a decade. In comparison with the University of Illinois PLATO system and the Air Force Advanced Instructional System, Navy CMI represents the largest of these approaches and seems a natural candidate for both its planned expansion and its further deployment in the future. While each of these three computer based systems has its own unique purposes, goals, and implementation characteristics, which leads one to recommend their continuance, the Navy CMI system is yielding performance and cost benefits that are especially attractive during the mid '70's.

The future of the Navy CMI system is already designed. It shall grow to support 17,000 students by 1980. During the course of this study, new enhancements have been identified. Classifying these under approaches representing instructional strategies and instructional systems development activities, a sensible re-infusion of proven R&D prototypes would be highly cost beneficial during the coming years.

Thus, in a sense, this monograph ends where it begins; that is, in a realization that research and development can again contribute to this outstanding system which fortunately has been designed to infuse new ideas and concepts while maintaining its high cost beneficial impact.

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Appendix A

Review of CMI Projects

The development of computer managed instructional systems began in approximately 1967 (Molnar and Sherman, 1969). The development of these systems requires adequate support over an extended period of time; therefore, they are still in an evolutionary stage. The development is also dependent on the "state of the art" in each of the many components which must be integrated within the CMI system. For example, the advances in computer technology have been such that systems must be continually evaluated and revised. This is particularly true since many of these advances are providing additional capabilities at lower costs. Some of the significant computer developments have been reported by the MITRE Corporation (Stetten, Morton, and Mayer, 1970).

Subsequent sections of this review will focus on (1) conceptualizations of CMI, (2) five large scale projects which are representative of developments in CMI within the civilian educational sector, and (3) military applications of CMI. The military projects are not described in detail in this section as the development of the largest of these, Navy CMI, is developmentally and summatively represented in the present report as well as in a more intensive experimental assessment of the project (Carson et al., 1975). In turn, the Advanced Instructional System of the Air Force is described in Chapter 8 of this report. While there are a number of other significant military CMI projects (e.g., NAS, Lamoore; NAS, Miramar; USASCS, Ft. Monmouth;

NCAS, Twentynine Palms; etc.), their key features are subsumed under prior sections of this document.

1.0 Conceptualizations of CMI

Although various investigators have offered somewhat differing descriptions of CMI, there is a consensus of conceptions that CMI is inextricably involved with the individualization of instruction. Specifically, CMI is viewed as a methodology for realizing the potential of computers in supporting individualization of the educational process.

Glaser (1969) offers a general instructional model which he presents as a sequence of six operations, all of which could be subsumed under the heading, "individualized instruction." Though this general model can be implemented along a continuum of varying degrees of automation, it is suggested that "automation can be a significant aid to the conduct of an individualized system and to the collection of research data so that the system can be improved (Cooley & Glaser, 1969)." For these authors, CMI is conceptualized as a means of implementing those operations which characterize an individualized instructional model.

Still within an individualized framework, Jerman (1970) offers a slightly different formulation from that discussed above. This formulation regards CMI--computer mediated instruction--as being closely related to the concept of multimedia instruction. The most important distinction between the two concepts is that in computer-mediated instruction, the sequence of topics must be under computer control, even when the student is off-line. The function of this system as visualized by Jerman is to (1) introduce a topic, (2) test, (3) prescribe appropriate off-line materials for study, (4) review the off-line material, (5) retest, (6) report to the teacher, and (7) introduce a new topic, etc.

Perhaps the most inclusive conceptualizations regarding CMI have been formulated by co-investigators at Florida State University. Dick (1969) describes CMI as:

> The overall management of learning materials and evaluation of the students who are participating in a training program where the instruction is not primarily conducted by the computer, but through the use of other types of self-instructional materials.

Hansen (1970) includes the major educational functions of (1) information retrieval, (2) scientific computing, and (3) computer support of instruction within the broader concept of an information management system. The last of these major functions, viz., computer support of instruction, encompasses CMI, computer-assisted instruction (CAI), and learning simulations. Further, it is Hansen's contention that CMI offers the most cost effective model as well as the greatest potential for subsuming the other two types, i.e., CAI and learning simulations (Hagerty, 1970).

The most significant aspect of FSU's approach to CMI is that the majority of the diagnostic evaluations and remedial prescriptions occur within a computer terminal-oriented interaction between the student and the CMI system. This technique insures real-time information exchange between the student and the system as well as immediately providing the student with his next learning assignment. Thus, the interactive terminal is the vehicle by which the individualization process under CMI is implemented.

The Navy definition of CMI is found in OPNAVINST 1500.39: "A system in which a computer is used to route a trainee through a series of instructional materials, presented by various media, so as to be best suited to his particular needs and abilities." The instruction also defines key words and terms such as "trainee," "instructional material," etc., in such a way that the complete definition is contained within the instruction (TAEG, 1974).

2.0 Civilian CMI Projects

Project PLAN. Project PLAN (Program for Learning in Accordance with Needs) was originated in 1966 through a joint venture involving the American Institutes for Research, the Westinghouse Learning Corporation, and twelve school districts throughout the country (Flanagan, 1970). It has now spread to 24 cities involving 20,000 students (Rogers, 1971).

> The proposed function of the new educational program is to provide a flexible system in which the student can be assisted to take as much responsibility as possible in the planning and carrying out of his own educational development (Flanagan, 1970, p. 2).

The five major components of the PLAN system are: (a) a set of educational objectives; (b) learning methods and materials; (c) evaluation; (d) guidance and individual planning; and (e) teacher development (Flanagan, 1970).

The role of the computer in PLAN involves a great variety of functions. The computer processes the daily tests taken by the students and provides print-outs of these results for the teachers. These data are used to constantly update and revise the student's program of studies. A weekly status report is also provided. In addition to the daily and weekly processing functions, the computer assists in registration of the student and in the actual planning of his course of study, including the placement of the student in the program of studies, establishing a quota in terms of numbers of modules to be completed, and a selection of the actual modules of instruction to be received by the student (Flanagan, 1970). The constant updating and revision of student data and the planning and prescriptive usage are critical features in making this type of computer application practical. In an effort to facilitate the flow of information to and from the computer, each of the Project PLAN schools has recently received a terminal through which the teachers can interact directly with the computer (Rogers, 1971).

System Development Corporation/Southwest Regional Laboratory. Working outside the realm of individualized instruction but designed to assist teachers in a traditional elementary school setting achieve a measure of individualization, a CMI effort was originated under the joint sponsorship of the System Development Corporation and the Southwest Regional Laboratory for Educational Research and Development (Silberman, 1969). This CMI system was designed to help the teacher monitor the progress of the students and make decisions as to the pace of instruction, the grouping of children, the sequence of lessons, and the individualization of instruction. The four primary components of the information management system are objectives, tests, reports, and prescriptions. It helps teachers by providing information about each child's achievement, suggesting activities to help a pupil understand a lesson, and providing a framework for making decisions on classroom management (Geddes & Kooi, 1969).

Individually Prescribed Instruction. Perhaps the most far-ranging effort in the CMI field was the Individually Prescribed Instruction (IPI) project instituted in the Oakleaf School System in Pittsburgh by the Learning Research and Development Center of the University of Pittsburgh. The IPI program is based on an instructional model consisting of the following sequence of operations:

> 1. The goals of learning are specified in terms of observable student behavior and the conditions under which this behavior is to be exercised.
> 2. Diagnosis is made of the initial capabilities with which the learner begins a particular course of instruction. The capabilities that are assessed are those relevant to the forthcoming instruction.
> 3. Educational alternatives adaptive to the initial profile of the student are presented to him. The student selects or is assigned one of these alternatives.
> 4. Student performance is monitored and continuously assessed as the student proceeds to learn.
> 5. Instruction proceeds as a function of the relationship between measures of student performance, available instructional alternatives, and criteria of competence.
> 6. As instruction proceeds, data are generated for monitoring and improving the instructional system (Cooley & Glaser, 1969, p. 96).

Automation is not a prerequisite for the implementation of the IPI model, and the project initially operated in the nonautomated form, much as it is being used in school systems across the country at present (see RERS Reports). After three years of operation in the nonautomated form, batch-process computer capabilities were added to the program in the form of a Management Information System (MIS).

> There are four major functions which the MIS can provide in an individualized school: (1) collect data; (2) monitor student progress; (3) provide prescriptions; and (4) diagnose student difficulty. These functions have two primary objectives: to increase

> the effectiveness of the model for individualizing instruction and to maximize the productivity of the teacher operating the IPI system (Cooley & Glaser, 1969, p. 106).

Through supporting the IPI instructional system with the functions of the MIS, IPI/MIS has been shown to be one of the leading projects in the research and implementation of individualized computer-based instruction. Cooley and Glaser (1969) admit that a shortcoming of the IPI/MIS system is that each school has only one terminal, and it is not in the classroom. They speculate that the next step in the development of IPI/MIS is to add classroom terminal capability so that both students and teachers will have access to computer terminals. The paper on computer-based testing by Ferguson (1970), an associate of Cooley and Glaser, indicates that IPI/MIS is moving in that direction at the present time.

Thus we can see that IPI/MIS is unique in that it is the only project which has existed in a nonautomated form, has moved to batch-process CMI, and is now moving into the other CMI mode, which was earlier described as terminal-oriented CMI.

Instructional Management System (IMS)

Coulson (1969) reports that the primary purposes of the computer-assisted instructional management (CAIM) system are to help the teacher monitor student performance and make management decisions about meeting each student's instructional needs. The instructional process is not managed by computer but by a teacher who is aided by information provided by a computer. The computer is not used as a teaching device and does not communicate directly with the student in any way.

The initial IMS effort at the first grade level provided the following functions.

1. Course objectives were specifically defined and measured by multiple choice tests which were optically scanned.

2. The directions for taking the test were contained on audio tapes and were administered on an individual basis through headsets.

3. Tests were collected twice each day and were automatically evaluated against mastery levels for one or more behavioral objectives.

4. The teacher received computer prescriptive print-outs for each student the following morning at the latest.

5. Summary reports were provided periodically and/or upon request.

Functions are also being developed which will provide computer generated exercises where existing materials were found to be inadequate.

Dr. Coulson noted that there are several advantages of the Instructional Management System over tutorial Computer-Assisted Instruction (CAI). Existing resources can be utilized more effectively, and neither major reorganization of the classroom nor large quantities of new equipment or instructional material are required. CAIM can be implemented much more speedily than CAI in most schools. Where individualized study materials are used, the feedback to the student may compare favorably with that provided by CAI. CAIM is designed with the teacher as its hub, thereby posing less of a threat to the teacher than CAI. The most obvious advantage of CAIM over CAI is its cost. General estimates indicate that CAI is ten to fifty times more expensive than CAIM.

The three minimum requirements of a legitimate CAIM system are defined as:

1. The system must measure student performance at relatively short intervals.

2. Evaluation should be tied to a set of specified learning objectives which are defined in behavioral terms.

3. Specific remedial action should be recommended to the teacher.

Florida State University's Computer Managed Instruction Project

According to Hansen et al. (1973), throughout the duration of the Themis/ONR contract there was a concurrent set of investigations in computer-assisted instruction (CAI) and computer-managed instruction (CMI). The primary purpose of the investigations of CMI was to determine its training effectiveness and associated cost benefit outcome in comparison with CAI and other more conventional means of instruction. As pursued at FSU, computer-managed instruction involves the following:

1. diagnostic assessment and the assignment of individualized learning prescriptions,

2. the use of CAI for practice and remedial purposes,

3. the use of simulation for role and decision-making training purposes,

4. the use of the computer for ease and objectivity of curriculum development, and

5. the development of a record system so that the individualized training process could be effectively monitored and managed.

Within this CMI conceptual context, a number of studies were pursued. All of these studies indicated that CMI at the collegiate level is highly feasible, cost effective, and provided for learning results similar to CAI. However, due to the mastery level learning approach utilized in the instructional materials, the relationship of individual difference variables to learning rate or performance was more limited. Where extensive media and recitation sections were used, the effects of individual difference variables seemed to be more pronounced. Finally, learning attitude toward the instructional materials was quite positive and could be manipulated by the form of training.

In turn, investigations of CAI indicated that it is useful in a number of technical training areas. It proved especially useful for dynamic graphics such as found in engineering dynamics. However, while CAI was shown to be viable in areas like chemistry, the results did not tend to exceed those found in CMI.

It is important to note the fact that the development process for CMI, while not quite as demanding as that of CAI, still was considerable. The dependency on a sound training model, formative evaluation, and effective monitoring of students in an individualized mode seem to be the critical factors in the design and implementation of CMI.

From this, consequently, the following research generalizations can be derived:

1. Terminal-oriented computer-managed instruction has been shown to be more effective than conventional instruction and less costly than computer-assisted instruction.

2. The most significant gains in the quality of instruction have not necessarily been due to the use of computers, but have been through the implementation of systematic approaches to the training process

required for application of the computer.

3. Although the computer provides the instructional developer with more information about the instructional process than has been available, the revision process remains the least well understood and utilized component of the systems approach; however, the provision for systematic, reliable data now allows us to turn our attention to this problem.

4. Interdisciplinary collegiate development teams will not necessarily produce better computerized instructional materials than those produced by conceptually integrated teams.

3.0 Military Applications of CMI

Fletcher et al. (1975) reports that there is a variety of research, development, and implementation effort in the three services which include CMI. The Army Computerized Training System (CTS) and Air Force Advanced Instructional System (AIS) will have CMI capabilities. However, these systems may be limited in their CMI applications because they are designed to permit rapid response times to student inputs, and they may provide insufficient file support for some types of CMI. The Computer-Assisted Instruction Study Management System (CAISMS) (University of Illinois) also includes both CAI and CMI.

A six-month analytical survey and study was conducted by the Training Analysis and Evaluation Group (TAEG) of the Naval Training Equipment Center. The principal conclusions of the study (Middleton, Papetti, and Micheli, 1974) are quoted below:

"a. There is no alternative for the Navy but to go to CMI if any significant number of its over 4,000 courses are to become self-paced and individualized (which is the trend of current educational technology)." (p. 63)

"b. Preliminary tradeoff analyses made during this investigation reveal that a combination of minicomputers (strategically located to perform the routine tasks of CMI) and a central computer system (for high level management information processing) is more cost effective than a single large-scale centralized computer." (p. 63)

"c. A minicomputer for small, remote classes is feasible.... it is proposed that CMI training in remote sites be linked together via land lines. In this concept, a greater number of managers and students can utilize the capabilities of CMI and have a more cost-effective system." (p. 64)

"d. The use of shipboard tactical computers for managing individual training has long been desired by the training community. However, numerous technical and logistical problems, as well as priorities placed upon the use of shipboard computers by higher authorities, have allowed relatively little training via operational computers aboard ships .... the state-of-the-art is advancing at such a pace in the mini- and micro-computer field that in the near future the market price for these systems will be such that it will be economically more advantageous for ships to have a dedicated system for education, rather than implementing a retrofit program to use operational equipment and computers for CMI." (p. 64-5)

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APPENDIX B

MEMPHIS STATE UNIVERSITY
COMPUTER-MANAGED INSTRUCTION SURVEY
INSTRUCTOR QUESTIONNAIRE

The purpose of this survey is to obtain the professional judgment of instructors concerning the Navy's CMI program. The information from the survey will be used to describe Instructors' perceptions concerning CMI and to determine needed improvements. The results will provide the basis for further planning and substantiation of the Navy's CMI program.

Please respond to the items as accurately and honestly as you can. All responses will be confidential; you are not asked to identify yourself on the questionnaire. Hopefully, the items on the questionnaire are clearly stated. If you have difficulty with any of the questions, you can contact Dr. Clyde Smith (Base, ext. 5429; Outside, 872-4976).

Thank you for your assistance.

Part I. Demographic Data

1. Age

____ a. Less than 21 ____ d. 31 - 35

____ b. 21 - 25 ____ e. 36 - 40

____ c. 26 - 30 ____ f. over 40

2. Years in military

____ a. Less than 2 years ____ c. 6 - 10 years

____ b. 2 - 5 years ____ d. more than 10 years

3. Status (Present)

____ a. Enlisted ____ d. Civil Service

____ b. Warrant ____ e. Other

____ c. Commissioned

4. Years experience with computers

____ a. Less than 1 ____ d. 7 - 9

____ b. 1 - 3 ____ e. 10 or more

____ c. 4 - 6

5. Present educational status

_____ a. did not finish high school

_____ b. high school diploma/G.E.D.

_____ c. some college experience

_____ d. college diploma

_____ e. advanced degree

Part II. Opinionnaire

Check only one answer for each question, unless otherwise instructed.

1. In comparison to all of the training in which your service is currently engaged, indicate the extent to which you think it is using computers to assist in the instructional process.

_____ a. 0 - 5%

_____ b. 6 - 10%

_____ c. 11 - 20%

_____ d. 21 - 30%

_____ e. 31 - 50%

_____ f. greater than 50%

2. With regard to your answer to question #1, to what extent do you feel computers should be used to assist in instruction?

_____ a. much more than now

_____ b. slightly more than now

_____ c. about the same as now

_____ d. slightly less than now

_____ e. much less than now

3. Projecting to 10 years from now, how do you think the extent of computer usage in instruction will compare to today's usage?

_____ a. much more

_____ b. slightly more

_____ c. about the same

_____ d. slightly less

_____ e. much less

4. To what extent do you agree or disagree with this statement: "As far as the military is concerned, the feasibility and effectiveness of CMI are no longer in question. Our goal now is to find the best ways of implementing computerized instruction."

_____ a. strongly agree

_____ b. agree

_____ c. no opinion

_____ d. disagree

_____ e. strongly disagree

5. What do you perceive to be the two most significant problems (or barriers) relating to the present use of computer technology in military training? (Check two)

____ a. cost ____ d. insufficient hardware technology

____ b. instructor attitudes ____ e. organizational climate

____ c. student attitudes ____ f. other (specify) ____________

6. Given a choice, which one of the following instructional modes would you prefer to use for the courses in which you presently are involved?

____ a. conventional mode - classrooms, blackboards, textbooks, etc. ____ d. programmed manuals

____ b. CMI ____ e. other (specify) ____________

____ c. tutorial CAI

7. What type of student do you feel benefits most from computerized instruction?

____ a. above average in learning ability

____ b. average in learning ability

____ c. below average in learning ability

____ d. all benefit about the same

8. How would you evaluate the influence on learning outcomes of instructors in CMI compared to the influence of conventional classroom teachers?

____ a. considerably more influential ____ d. slightly less influential

____ b. slightly more influential ____ e. considerably less influential

____ c. about the same

9. Indicate your reaction to the following statement:

"Military training today is still very labor intensive. In the future, the augmentation of instructors by machines, such as computers, offers the most likely alternative to increase productivity in training."

____ a. strongly agree ____ d. disagree

____ b. agree ____ e. strongly disagree

____ c. not sure

10. Indicate your reaction to the following statement:

"In the future, motivation for enlisting in the service could be increased as a result of modern training methods, such as computer-based instruction."

_____ a. strongly agree
_____ b. agree
_____ c. not sure
_____ d. disagree
_____ e. strongly disagree

11. In your opinion, which one of the following activities requires the most time and effort from the learning supervisor?

_____ a. basic administrative responsibilities
_____ b. answering questions from students
_____ c. providing remedial assistance
_____ d. counseling students
_____ e. disciplining students
_____ f. other (specify) ____________________

12. What are the top three benefits or advantages of CMI? (Choose 3)

_____ a. It saves time.
_____ b. It saves money.
_____ c. It produces quality instruction.
_____ d. It is favored by students.
_____ e. It has the flexibility to handle varying training loads.
_____ f. It reduces the dropout rate.
_____ g. It offers greater uniformity in the quality of training.
_____ h. It provides greater assurance that educational objectives will be met.
_____ i. It is adaptable to individual differences.
_____ j. Other (specify) ______________________________

13. What two categories of personnel are likely to benefit most from CMI? (Choose 2)

_____ a. enlisted men learning entry level skills

_____ b. enlisted men beyond the entry level

_____ c. cadets

_____ d. officer candidates

_____ e. officers at the basic or advanced level

_____ f. other (specify) ____________________

14. Recent official surveys indicate that: "Compared to the draftee, today's typical enlistee has a lower educational level, is several years younger, and tends to sign up for a unit of choice which allows units home on weekends." Therefore, training by CMI will be more appropriate than conventional methods.

_____ a. strongly agree

_____ b. agree

_____ c. not sure

_____ d. disagree

_____ e. strongly disagree

15. Select one or more ways in which you think instructors, working with computer based training systems, should be selected for assignment.

_____ a. according to prior knowledge of computers

_____ b. according to prior teaching experience

_____ c. because they volunteer

_____ d. according to MOS, AFSC, NEC, or sub-specialty code or skill identities

_____ e. according to personality and attitude test scores

_____ f. without too much emphasis on any of the above, but more according to availability

Part III. Open-ended Questions

Please try to make your answers brief and concise; if possible use a few key words or short sentences.

1. How important is the role of the instructor in a CMI system?

2. How successful was on-the-job training in preparing you for CMI?

3. How useful was Instructor Training School in preparing you for your CMI functions in the area of:

   a. instructional techniques

   b. instructional materials

   c. testing

   d. Instructional System Development

4. What proportion of the students in your CMI program show some evidence that they are not really trying to succeed?

5. What techniques do you use to motivate students when using CMI?

6. Overall, how successful has CMI implementation been in your training program?

7. Has CMI increased the productivity of your training program?

8. How successful is the CMI system in achieving instructional objectives of your training program?

9. What are the most successful features of the CMI system as it operates in your training program?

10. What are the least successful features of the CMI system as it operates in your training program?

11. If you have any additional comments (a word, a phrase, a sentence, or more) about CMI, please write them below: